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International application number: PCT/US04/026345

International filing date: 13 August 2004 (13.08.2004)

Document type: Certified copy of priority document

Document details: Country/Office: US
Number: 60/495,056
Filing date: 14 August 2003 (14.08.2003)

Date of receipt at the International Bureau: 06 October 2004 (06.10.2004)

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b)

World Intellectual Property Organization (WIPO) - Geneva, Switzerland
Organisation Mondiale de la Propriété Intellectuelle (OMPI) - Genève, Suisse

1228319

THE UNITED STATES OF AMERICA

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UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

October 01, 2004

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APPLICATION NUMBER: ***60/495,056***
FILING DATE: ***August 14, 2003***

Certified by

Jon W Dudas

Acting Under Secretary of Commerce
for Intellectual Property
and Acting Director of the U.S.
Patent and Trademark Office

PTO/SB/16 (10-01)
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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Expr ss Mail Label No. EU 982358560 US

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Mark	Shuster	Houston, Texas
D. Scott	Costa	Kingwood, Texas

[x] *Additional inventors are being named on the* one *separately numbered sheets attached hereto*

TITLE OF THE INVENTION (500 characters max)

EXPANDABLE PIPE

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

[ ] Customer Number 000027684 *Type Customer Number here* → *Place Customer Number Bar Code Label here*

OR

[x] Firm or Individual Name	Todd Mattingly				
Address	1000 Louisiana Street				
Address	Suite 4300				
City	Houston	State	TX	ZIP	77002-5012
Country	USA	Telephone	713-547-2301	Fax	713-236-5585

ENCLOSED APPLICATION PARTS ***(check all that apply)***

[x] Specification *Number of Pages* 39
[ ] Drawing(s) *Number of Sheets*
[x] Application Data Sheet. See 37 CFR 1.76
[ ] CD(s), Number
[x] Other (specify) Return Receipt Postcard

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

[ ] Applicant claims small entity status. See 37 CFR 1.27.
[ ] A check or money order is enclosed to cover the filing fees
[x] The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 08-1394
[ ] Payment by credit card. Form PTO-2038 is attached.

FILING FEE AMOUNT ($): $160.00

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.
[x] No.
[ ] Yes, the name of the U.S. Government agency and the Government contract number are: ____________________

Respectfully submitted,

SIGNATURE *Todd Mattingly /vmm*

Date 08/14/2003

TYPED or PRINTED NAME Todd Mattingly

REGISTRATION NO. *(if appropriate)* 40,298

TELEPHONE 713-547-2301

Docket Number: 25791.301

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

This collection of information is required by 37 CFR 1.51. The information is used by the public to file (and by the PTO to process) a provisional application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 8 hours to complete, including gathering, preparing, and submitting the complete provisional application to the PTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, Washington, D.C. 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Box Provisional Application, Assistant Commissioner for Patents, Washington, D.C. 20231.

PROVISIONAL APPLICATION COVER SHEET
Additional Page

PTO/SB/16 (02-01)
Approved for use through 10/31/2002. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Docket Number	25791.301

INVENTOR(S)/APPLICANT(S)		
Given Name (first and middle [if any])	Family or Surname	Residence (City and either State or Foreign Country)
Lawrence	Kendziora	Needville, Texas
Kevin	Waddell	Houston, Texas
Jose	Menchaca	Houston, Texas
Edward	Zwald, Jr.	Houston, Texas

Number 2 of 2

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EXPRESS MAIL NO. **EU 982358560 US**

DATE OF DEPOSIT: **August 14, 2003**

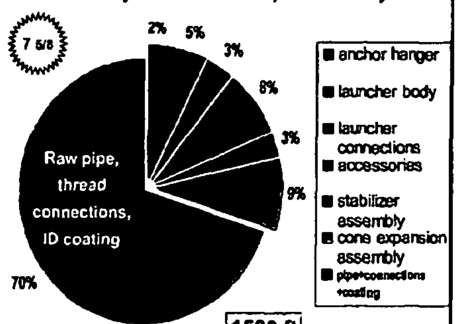
The Provisional Application for Patent Cover Sheet, Initial Information Data Sheet and the following thirty-nine (39) pages are being deposited with the U.S. Postal Service Express Mail Post Office to Addressee Service under 37 CFR §1.10 on the date indicated above and is addressed to: MAIL STOP PROVISIONAL PATENT APPLICATION, Commissioner for Patents, P. O. Box 1450, Alexandria, VA 22313-1450.

Vikki M. Meriwether (25791.301)	Vikki M. Meriwether
Name of person mailing paper and fee	Signature of person mailing paper and fee

Attn to # AFT - 2003.0019

Morris Shuster
6/30/03

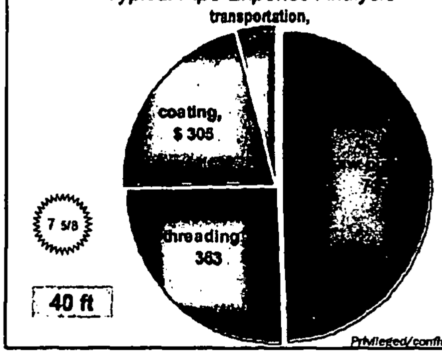
Preliminary Installation Expense Analysis



1500 ft

Privileged/confidential

Typical Pipe Expense Analysis



40 ft

Privileged/confidential

Parameters Required for Formability Evaluation

Stress-Strain Properties
- Optimum combination of the strength & elongation

Charpy V-notch Impact value
- Impact tests on notched specimens are used to predict the likelihood of brittle fracture

Stress Rupture (burst, collapse)
- Higher strength is better but decreased ductility/toughness with increased susceptibility to environmental cracking

Strain-hardening exponent (n - value)
- Material with higher strain-hardening exponent can avoid failure during tube expansion

Plastic strain ratio (r or Lankford - value)
- The ratio of the strains occurring in the width and thickness directions. In case greater than 1.0 will be more resistant to thinning and better suited to tubular expansion

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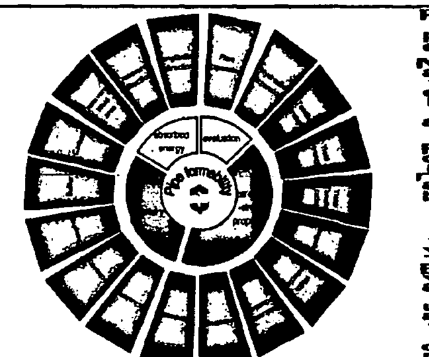

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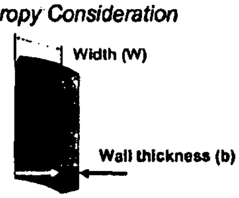
Pipe Anisotropy Consideration



$$r = \ln(w_f/w_o)/\ln(b_f/b_o)$$

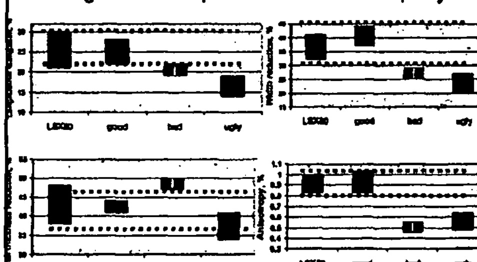
wk & wo - initial and final pipe width

bo & bk - initial and final wall thickness

r - anisotropy

Privileged/confidential

Dog Bone Sample Stress-Strain Property



Y/T ratio is less than 85%, Longitudinal elongation is more than 22%, Pipe width reduction is more than 30%, Anisotropy is more than 0.8

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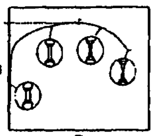
Expandability (?) Coefficient



$$r = \ln(w_f/w_o)/\ln(b_f/b_o)$$

$$f = r \times n$$

f - expandability coefficient
r - anisotropy
n – strain hardening exponent

Higher width to wall thickness reduction ratio can provides a better expandability performance

Privileged/confidential

n - Value Definition

(Strain-Hardening Exponent)

T. Altan (OSU)

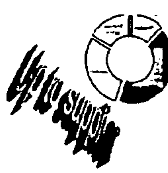
EGT Super Pipe Requirements

Absorbed energy (min) at -4°F(-20°C)

Longitudinal direction	80 ft-lb
Transverse direction	60 ft-lb
Transverse weld area	60 ft-lb

Flare expansion	45% min Crack-free
Mechanical expansion	Regular expansion forces
Tensile strength	60-120 ksi
Yield strength	40-100 ksi
Y/T ratio	50/85 %max
Elongation	35% min
Width reduction	40% min
Thickness reduction	30% min
Anisotropy	1.5 min

Carbon
Sulfur
Phosphor
Inclusions
Defects



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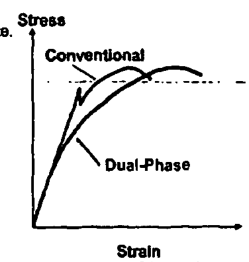
Dual Phase Steel

- Microstructure.
  - 15%-30% Martensite.
  - Ferrite
  - Retained austenite
- Composition.
  - 0.1%C, 1.2%Mn, 0.3%Si.
  - (0.5Cr, 1.5%Mn)



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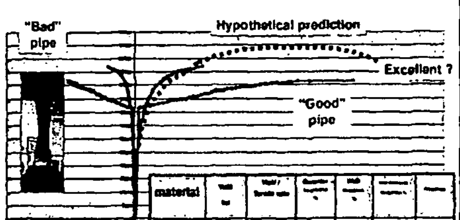
Engineering Stress vs. Strain Curve



material	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Good pipe	84.4	0.840	20.5	40.0	41.8	0.935
Bad pipe	73.7	0.87	13.5	20.4	37.5	0.48
Excellent	40/80	<0.5	>35	>40	>30	>1.5

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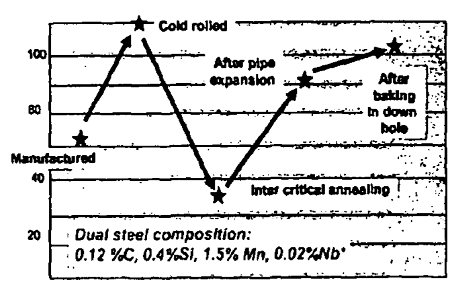
Yield Strength Transformation during Expandable for Dual Phase Steel Application (Hypothesis)



*K. Hulka

Privileged/confidential

Meeting Notes: May 20, 2003

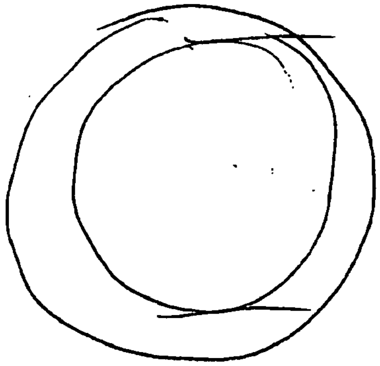
Discussion

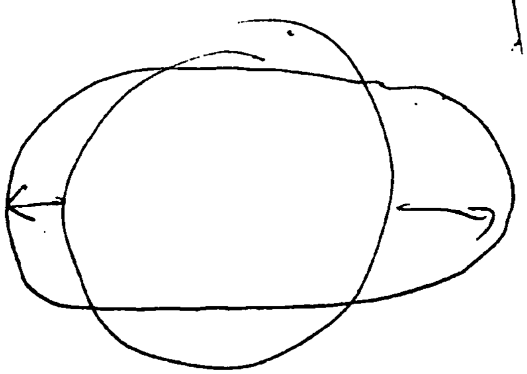
Enventure 50% Shell/Halliburton
400 People

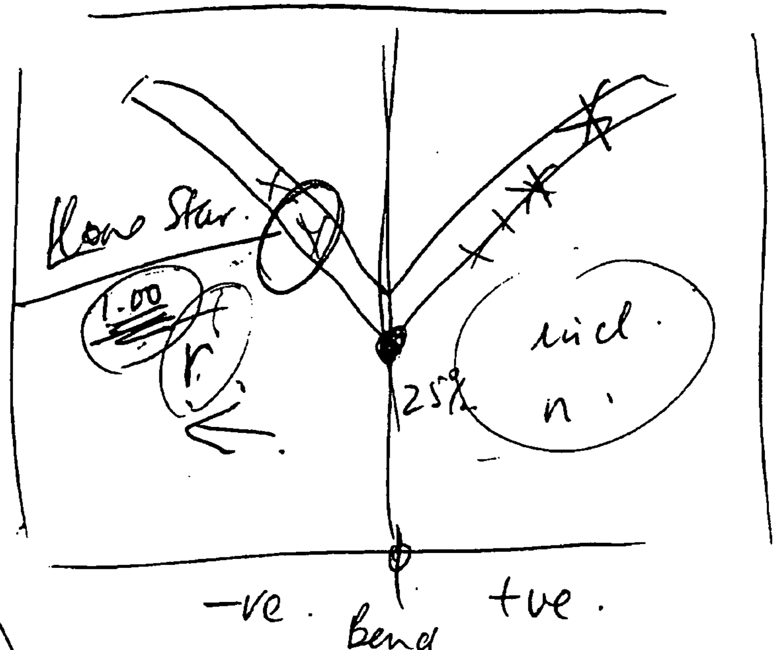
- Bob Hinkel
-

Mono dia . 20 – 40%.
.

- Baker Hughe
- Weatherford
- Schlumberger.



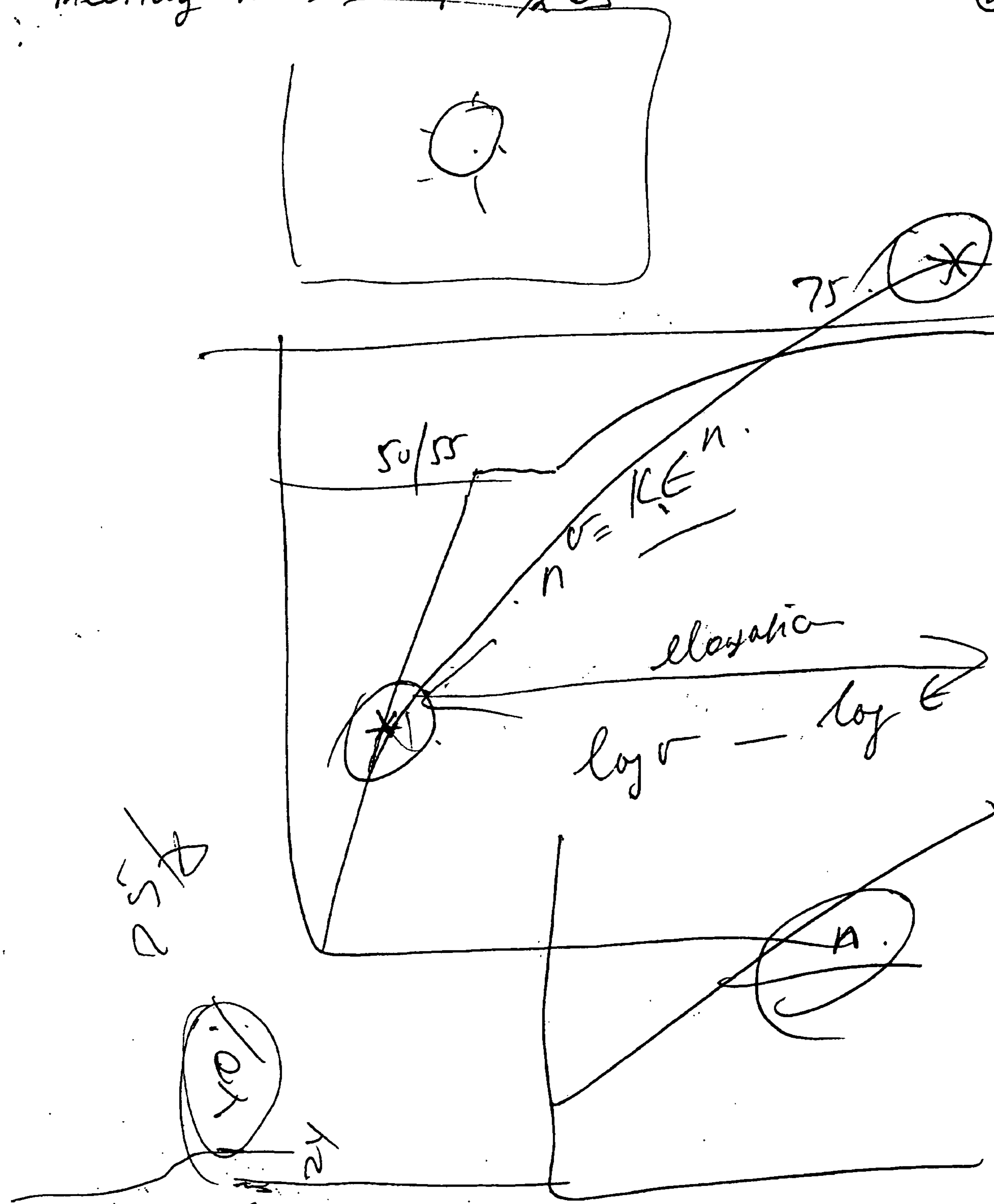




Attendee: J. Malcolm Gray
W. J. (Bill) Fazacker
(Microalloying Int) &
Mark Shuster
(Enventure)

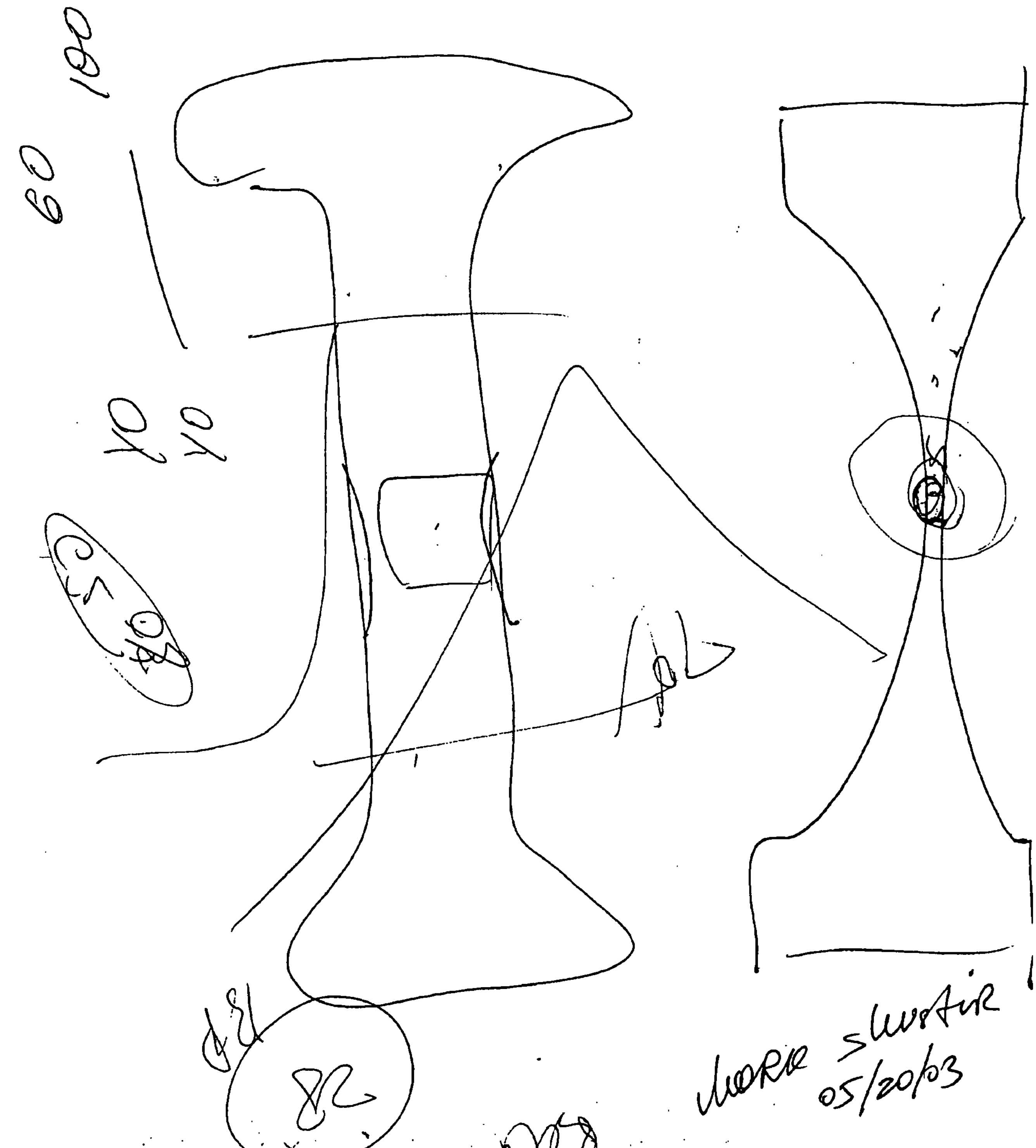
Mark Shuster 05/20/03

Meeting notes: May 20, 2003 ②



Discussion about optimization of the stress-strain curve for selection pipe for expandable tubular application 4

Mark Shuster 05/20/03



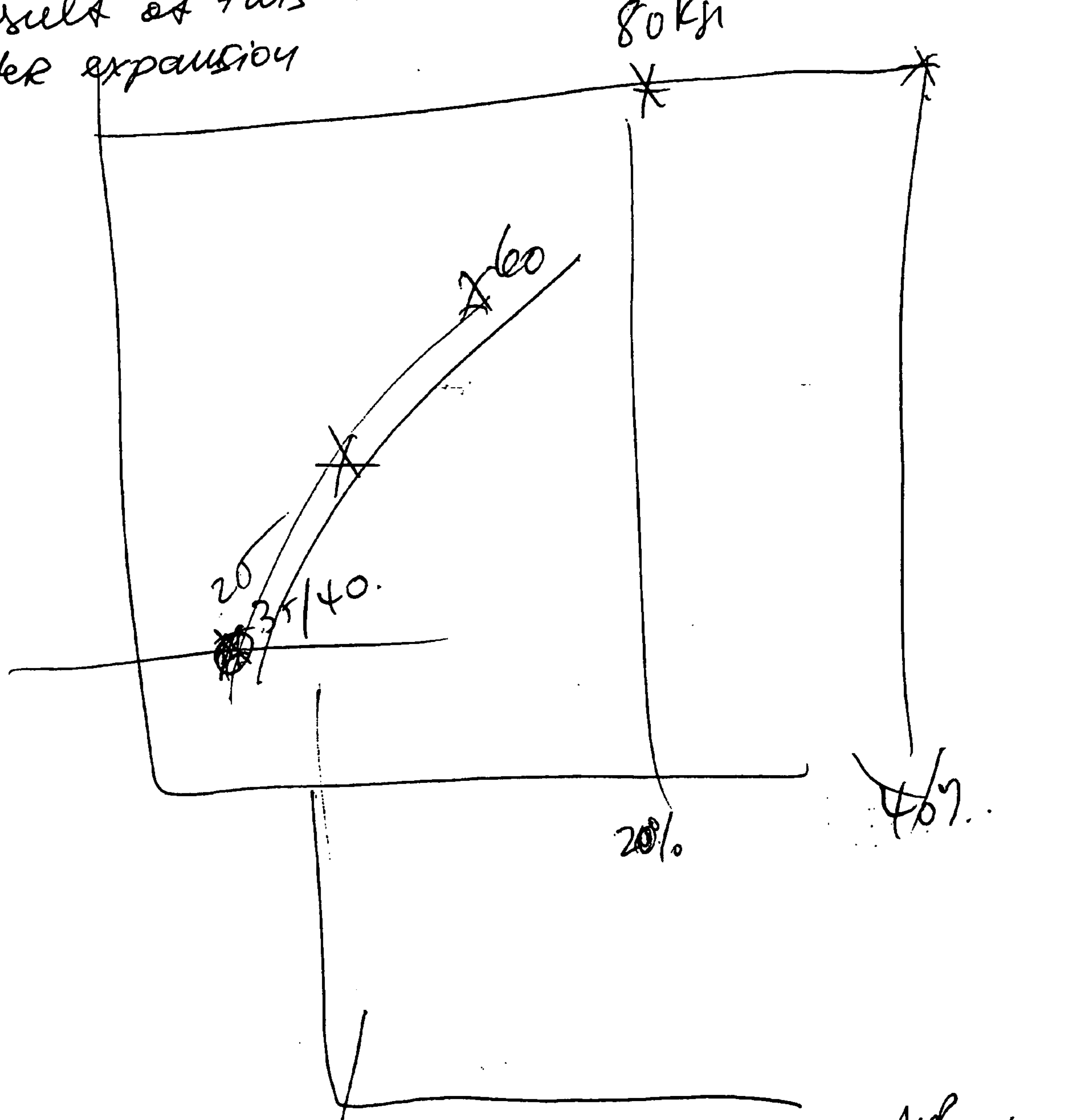
Mark Shuster
05/20/03

Methodology of the sample shape for evaluation of the stress-strain properties in longitudinal & transversal directions

Meeting notes

4

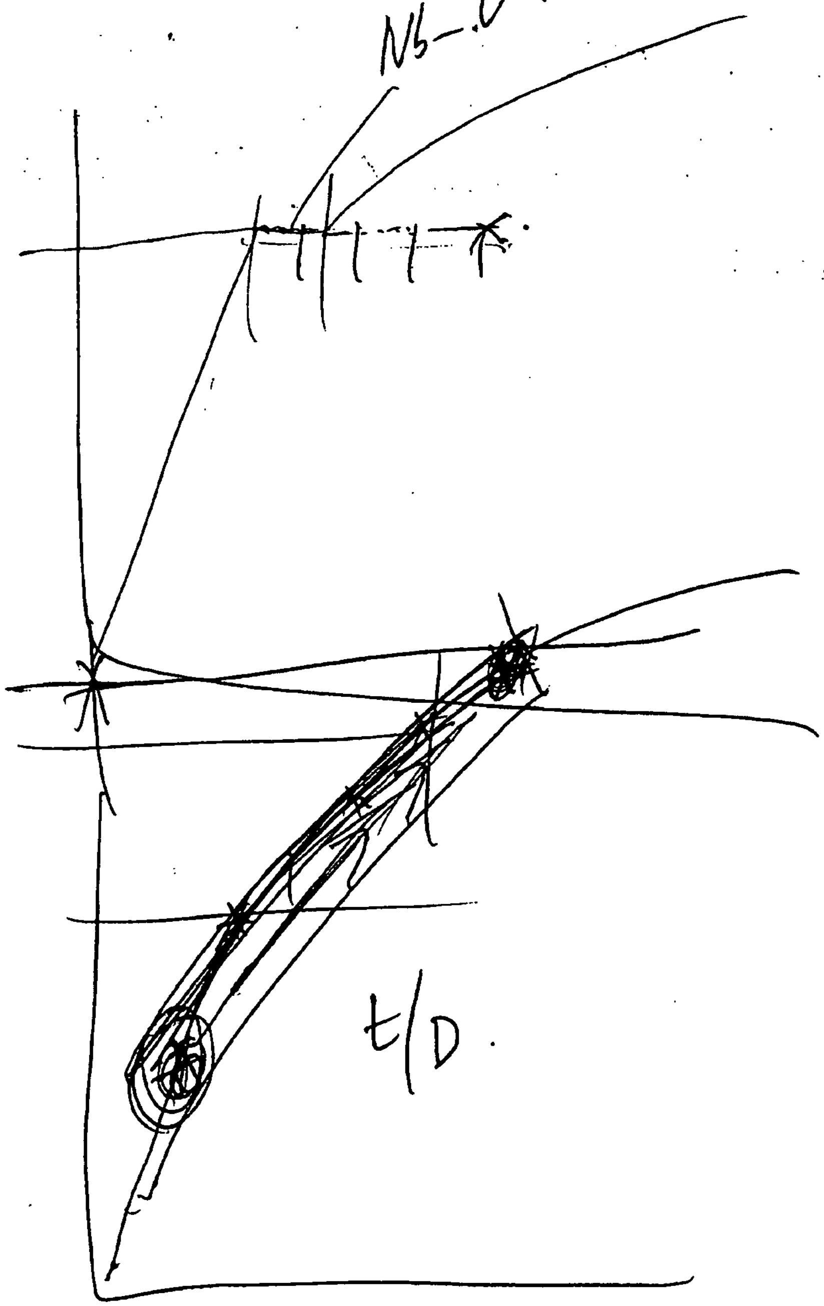
The main idea of future invention consists of application of the very formable steel with 35-40 ksi yield for expandable tubular. Special heat treatment with mechanical influence will provide a good cold work hardening and as a result of this we will receive 80 ksi yield after expansion



Mark Shuster 05/20/03 6

Meeting notes (5)

Discussion about application niobium and vanadium steel for expandall tubular

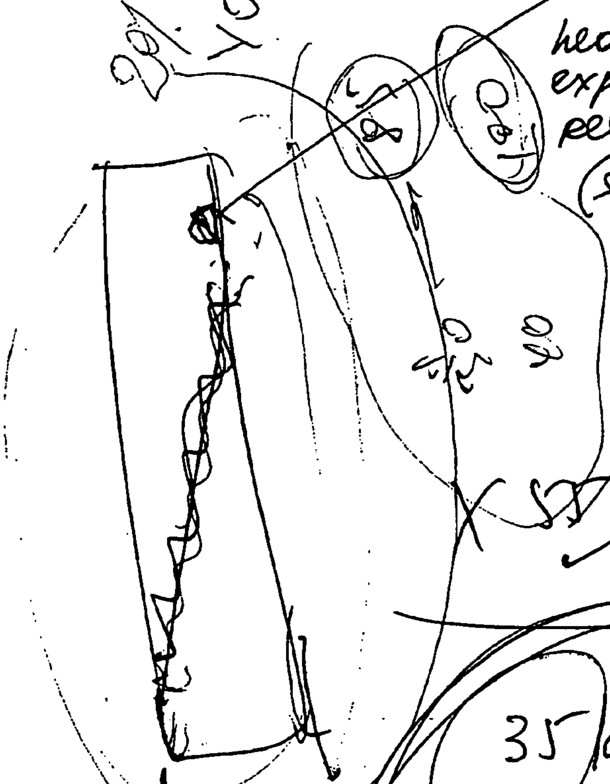


Mord Shuster
05/20/03

Meeting notes

(6)

20% 40%



connection can be heat treated before expansion to locally reach 60-70 ksi 30%.

(Scott Costa - the same day during discussion with Mark Shuster)

X55 ksi. Dual Phase.

Microstructure

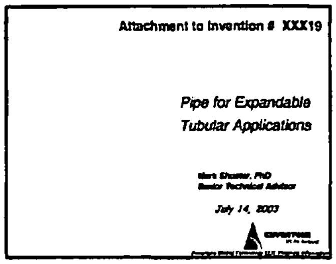
35 ksi — D

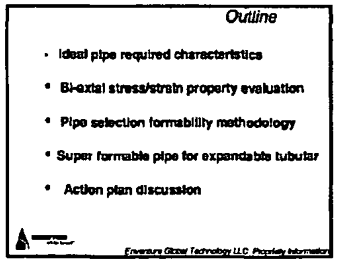
$7\frac{5}{8}$ 40%.

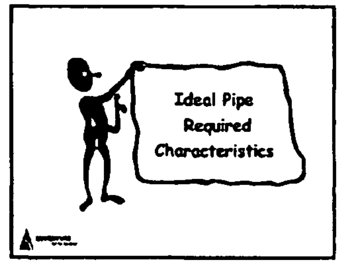
Discussion about $7\frac{5}{8}$ pipe with 40% expansion for monodiameter application and application of the dual phase steel and method how to do it.

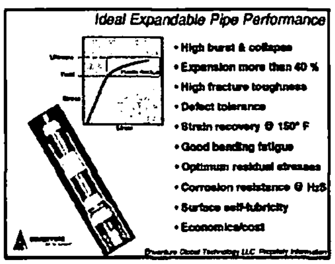
Mark Shuster 05/20/03 8

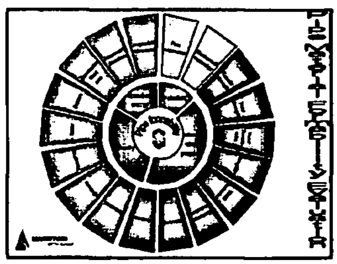
EGT-2003-19

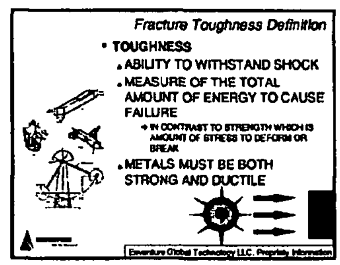


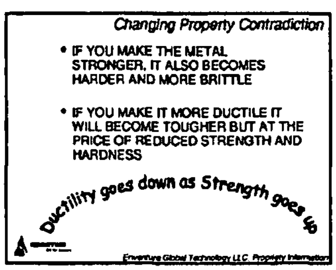


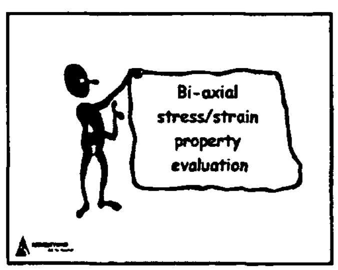


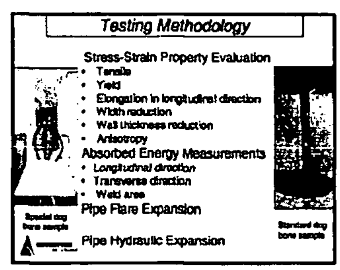




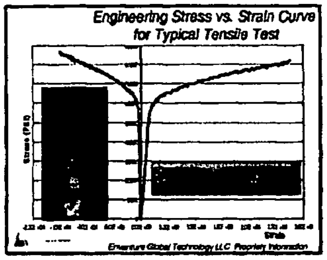


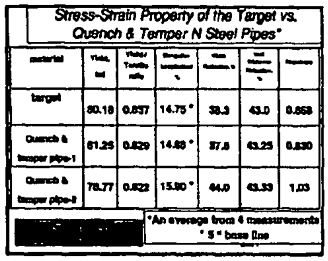






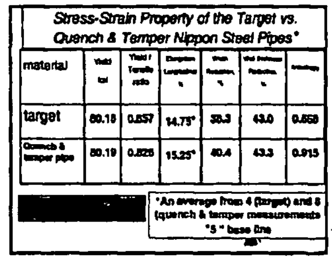
EGT-#4462-v1
Pipe_for_Expandble...





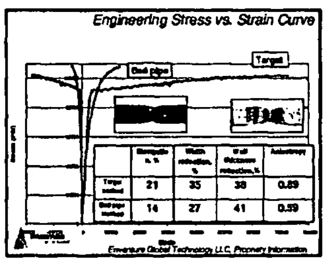
material	Yield, ksi	Yield / Tensile ratio	[illegible]	[illegible]	[illegible]	[illegible]
target	80.18	0.857	14.75 *	38.3	43.0	0.858
Quench & temper pipe-1	81.25	0.829	14.88 *	37.8	43.25	0.830
Quench & temper pipe-2	78.77	0.822	15.80 *	44.0	43.33	1.03

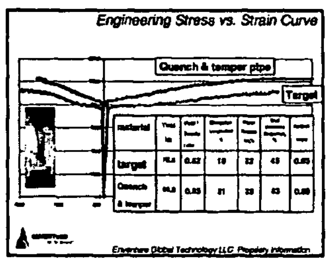
*An average from 4 measurements
* 5 " base line

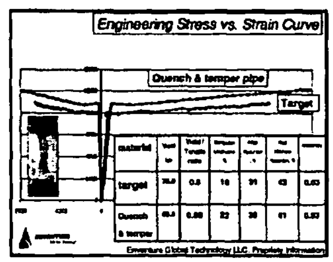


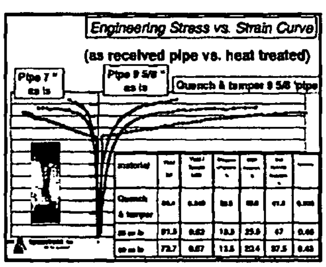
material	Yield ksi	Yield / Tensile ratio	[illegible]	[illegible]	[illegible]	[illegible]
target	80.18	0.857	14.75*	38.3	43.0	0.858
Quench & temper pipe	80.19	0.826	15.25*	40.4	43.3	0.915

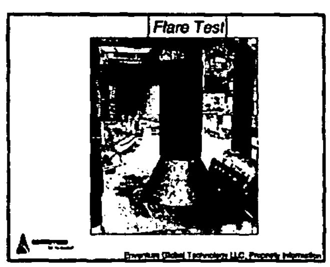
*An average from 4 (target) and 8 (quench & temper measurements
*5 " base line

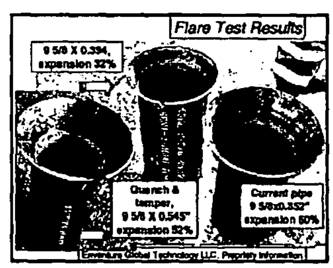


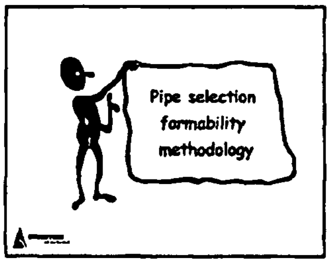


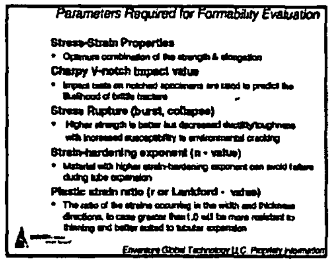









Pipe selection
formability
methodology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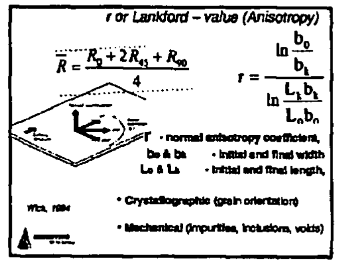
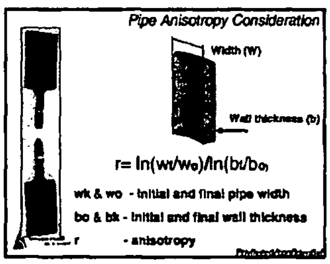
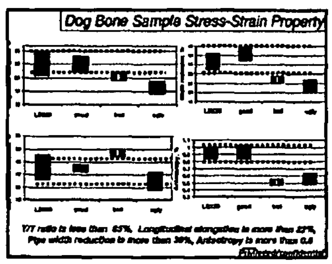
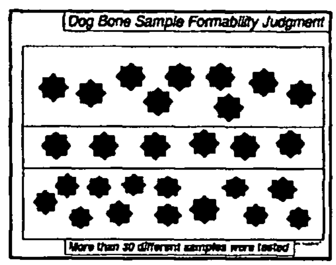
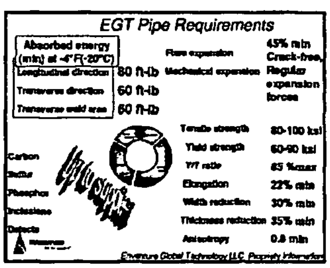
Charpy V-notch impact value
Stress Rupture (burst, collapse)
Strain-hardening exponent (n - value)
Plastic strain ratio (r or Lankford - value)
Enventure Global Technology LLC Property Information

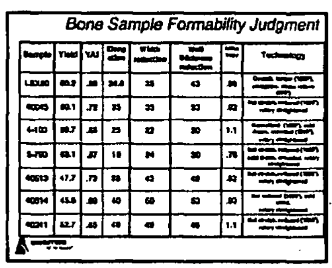

r or Lankford – value (Anisotropy)
$\overline{R} = \frac{R_0 + 2R_{45} + R_{90}}{4}$
$r = \frac{\ln \frac{b_0}{b_k}}{\ln \frac{L_k b_k}{L_0 b_0}}$
r - normal anisotropy coefficient,
b₀ & bₖ - initial and final width
L₀ & Lₖ - initial and final length,
• Crystallographic (grain orientation)
• Mechanical (impurities, inclusions, voids)

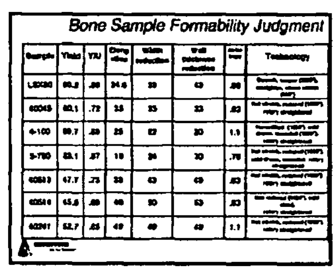

Pipe Anisotropy Consideration
Width (W)
Wall thickness (b)
r= ln(wₖ/w₀)/ln(bₖ/b₀)
wk & wo - initial and final pipe width
bo & bk - initial and final wall thickness
r - anisotropy

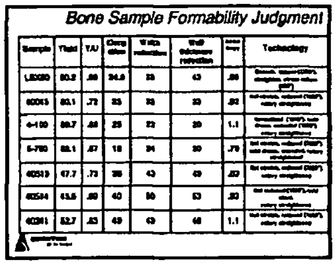

Dog Bone Sample Stress-Strain Property

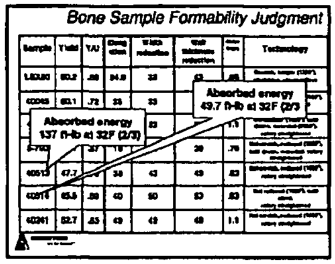

Dog Bone Sample Formability Judgment
More than 30 different samples were tested

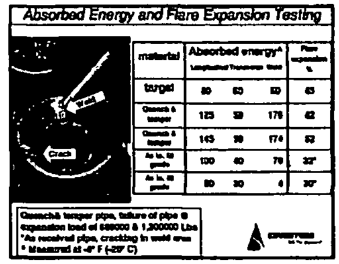

EGT Pipe Requirements
Absorbed energy (min) at -4°F(-20°C)
Longitudinal direction 80 ft-lb
Transverse direction 60 ft-lb
Transverse weld area 60 ft-lb
45% min
Crack-free,
Regular
expansion
forces
Tensile strength 80-100 ksi
Yield strength 60-90 ksi
Y/T ratio 85 %max
Elongation 22% min
Width reduction 30% min
Thickness reduction 35% min
Anisotropy 0.8 min
Carbon
Inclusions
Defects
Enventure Global Technology LLC Property Information

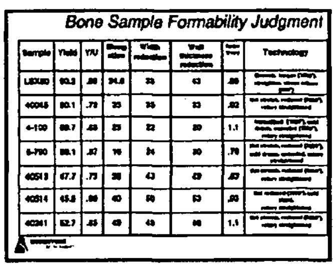

Bone Sample Formability Judgment
Sample
Yield
Technology
4-100
1.1

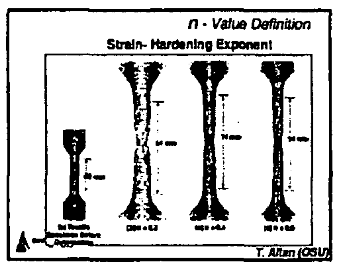

Bone Sample Formability Judgment
Sample
Yield
Technology
4-100
1.1

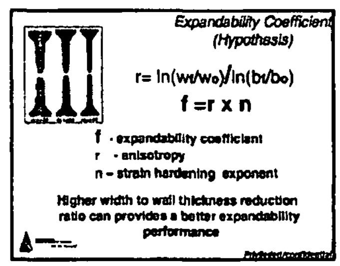

Bone Sample Formability Judgment

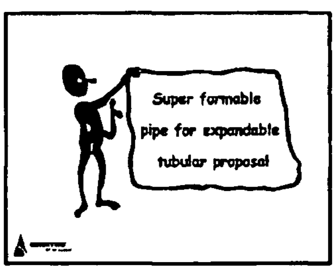

Bone Sample Formability Judgment
Absorbed energy
137 ft-lb at 32F (2/3)
Absorbed energy
49.7 ft-lb at 32F (2/3)

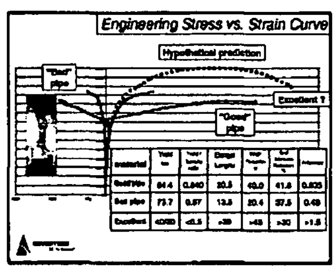

Absorbed Energy and Flare Expansion Testing
Crack
material
Absorbed energy*
target
* Measured at -4° F (-20° C)

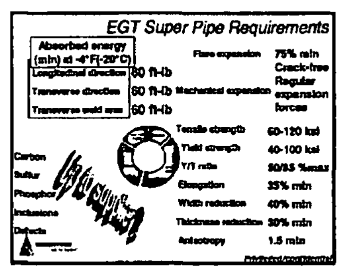

Bone Sample Formability Judgment


n - Value Definition
Strain- Hardening Exponent
T. Altan (OSU)

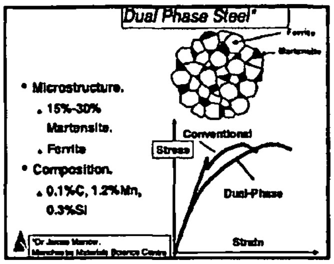

Expandability Coefficient
(Hypothesis)
r= ln(wf/wo)/ln(bf/bo)
f =r x n
f - expandability coefficient
r - anisotropy
n – strain hardening exponent
Higher width to wall thickness reduction ratio can provides a better expandability performance

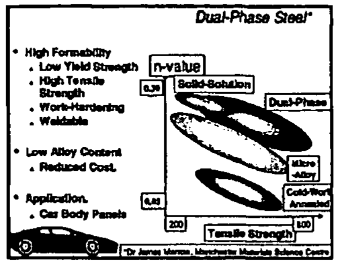

Super formable pipe for expandable tubular proposal

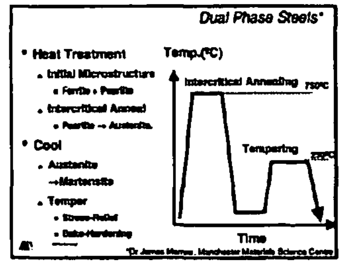

Engineering Stress vs. Strain Curve
Hypothetical prediction
"Bad" pipe
"Good" pipe
Excellent ?

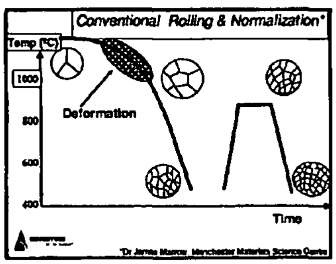

EGT Super Pipe Requirements
Absorbed energy
(min) at -4°F(-20°C)
60 ft-lb
60 ft-lb
60 ft-lb
75% min
Crack-free
Regular
expansion
forces
60-120 ksi
40-100 ksi
35% min
40% min
30% min
1.5 min
Carbon
Sulfur
Inclusions
Defects

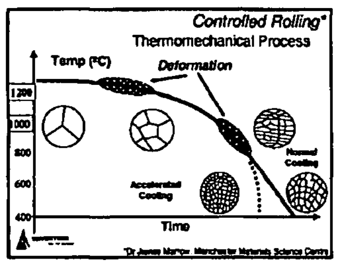
12

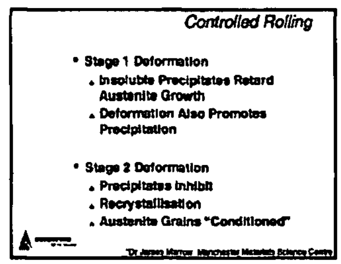

Dual Phase Steel*
Microstructure.
15%-30% Martensite.
Ferrite
Composition.
0.1%C, 1.2%Mn, 0.3%Si
Stress
Conventional
Dual-Phase
Strain

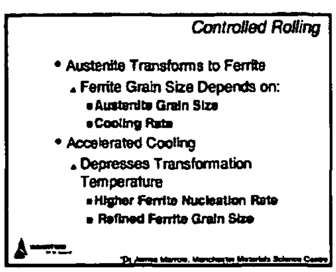

Dual-Phase Steel*
High Formability
Low Yield Strength
High Tensile Strength
Work-Hardening
Weldable
Low Alloy Content
Reduced Cost.
Application.
Car Body Panels
n-value
Solid-Solution
Dual-Phase
Tensile Strength

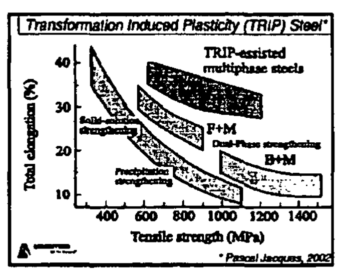

Dual Phase Steels*
Heat Treatment
Cool
Temper
Temp.(°C)
Intercritical Annealing
Tempering
Time

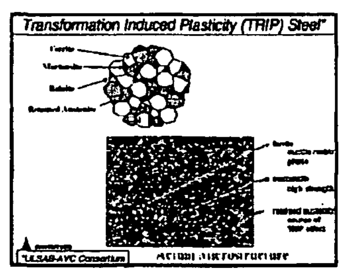

Conventional Rolling & Normalization*
Temp (°C)
1000
800
600
400
Deformation
Time

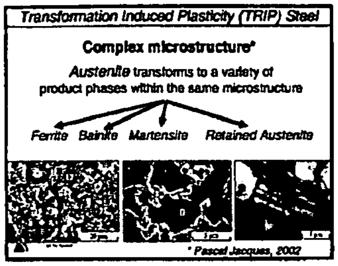

Controlled Rolling*
Thermomechanical Process
Temp (°C)
Deformation
1200
1000
800
600
400
Time

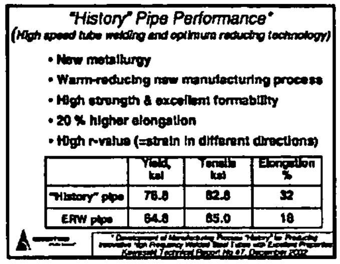

Controlled Rolling
Stage 1 Deformation
Insoluble Precipitates Retard Austenite Growth
Deformation Also Promotes Precipitation
Stage 2 Deformation
Precipitates Inhibit
Recrystallisation
Austenite Grains "Conditioned"


Controlled Rolling
Austenite Transforms to Ferrite
Ferrite Grain Size Depends on:
Austenite Grain Size
Cooling Rate
Accelerated Cooling
Depresses Transformation Temperature
Higher Ferrite Nucleation Rate
Refined Ferrite Grain Size

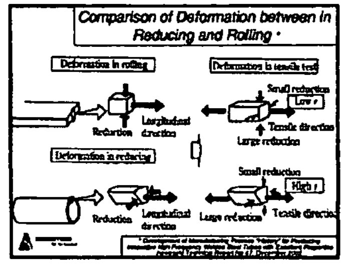

Transformation Induced Plasticity (TRIP) Steel*
TRIP-assisted multiphase steels
F+M
B+M
Total elongation (%)
40
30
20
10
400
600
800
1000
1200
1400
Tensile strength (MPa)
* Pascal Jacques, 2002

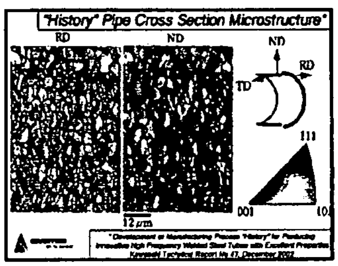

Transformation Induced Plasticity (TRIP) Steel*
*ULSAB-AVC Consortium

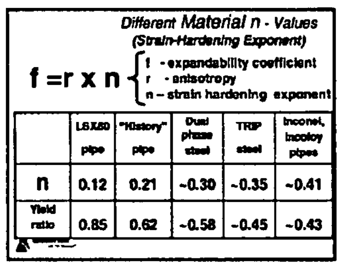




	Yield, ksi	Tensile ksi	Elongation %
"History" pipe	78.8	82.8	32
ERW pipe	64.8	85.0	18

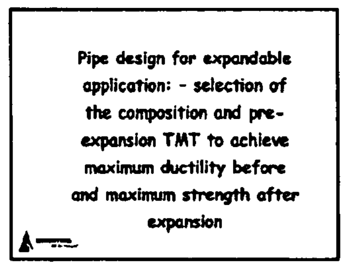


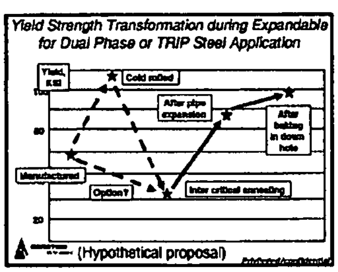




$$f = r \times n \begin{cases} f & \text{- expandability coefficient} \\ r & \text{- anisotropy} \\ n & \text{– strain hardening exponent} \end{cases}$$

	LSX60 pipe	"History" pipe	Dual phase steel	TRIP steel	Inconel, Incoloy pipes
n	0.12	0.21	~0.30	~0.35	~0.41
Yield ratio	0.85	0.62	~0.58	~0.45	~0.43





ECT-2003-23

7-18-2003
vmm

Vikki Meriwether

From: Mark Shuster

Sent: Friday, July 18, 2003 4:18 PM

To: Vikki Meriwether

Cc: Todd Mattingly; Larry Kendziora; Scott Costa; 'Grigoriy Grinberg'; Mark Shuster

Subject: Invention proposal

Connection for expandable tubular with deformable thread profile
(Invention proposal)

There are technical contradictions for expandable tubular connections. The thread needs to have enough strength for load carrying of the pipe string with a grade steel of at least 60 - 80 ksi yield with corresponding hardness (~20HRC). During expansion a lower yield material, 15-40 ksi, in the thread profile prevents or creates a bonding across the threads during expansion. The main idea of invention is a deformable thread profile of the connection for expandable tubular. This type of the contradiction could be solved by different designs, material and technology application providing easy plastic deformation and corresponding smashing of the thread profile surfaces. There are a lot of technical decisions which could provide such thread surface deformation.
The main are:

⇒ Soft insert application, such copper, aluminum or other soft metal. The other benefit of the application of the soft inner layer on connection cross section is different stress strain (residual stress on pipe ID and OD distribution which can provide tighter joint after expansion. Soft inner layer can be produced by insert, spraying, galvanizing, etc.

⇒ Localized thread surface annealing by induction treatment or torch flame. In the case of induction heat we can use high frequency to achieve thinner layer (less than 0.08") or low frequency for thicker annealed layer (more than 0.08'). Plastic deformation of the relatively softer thread surfaces will provide a better condition for localized scuffing (galling, scoring, seizure phenomenon) with following clinching of the tread surfaces during expansion

⇒ Special thread geometry (shape) with lower load capacity (groove, notches, etc) provides easy deformation during expansion (see attachment)

⇒ Special chemical or thermo chemical treatment to thread softening surfaces

⇒ Application of the active termite type of composition provides extra heat in contact between thread surfaces with following surface softening

The authors: M. Shuster, S. Costa, L. Kendziora – all Enventure
G. Grinberg (GS Engineering) –father of the original soft insert idea

Mark Shuster, PhD
Senior Technical Advisor
ENVENTURE Global Technology
16200-A Park Row | Houston, TX 77084

phone: 281.492.5039 | cell: 281.615.0770
main: 281.492.5000 | fax: 281.492.5050
mark.shuster@enventureGT.com
www.enventureGT.c m

ECT-2003-24

7-22-2003

Vikki Meriwether vmm

From: Mark Shuster

Sent: Tuesday, July 22, 2003 9:21 PM

To: Vikki Meriwether

Cc: Todd Mattingly; Kevin Waddell; Edwin Zwald; Jose Menchaca

Subject: A NEW PROPOSAL OR INVENTION

One of the main disadvantages or better say challenges for expandable tubular application is decreasing pipe collapse performance. This possible invention is leading to extended collapse performance for expandable tubular. Previous analysis of the different lubricants efficiency during mechanical expansion point that low friction lubricant (pipe ID solid film as well as special greases or combination of these options) significantly decrease an expansion load. This indicates an opportunity of thicker pipe application with the same affordable expansion forces. Additionally, low friction lubricant decrease residual stresses, increase shrinkage, slightly decrease pipe wall thinning (see attached power point presentation). All of these options improve collapse after expansion. The other resource of the collapse enhancement is special pipe material and heat treatment application provides low yield material characteristics during expansion but as results of high n-value (hardening exponent) high yield performance after expansion. Computer modeling prediction and calculation of the possible affordable pipe wall thickness and collapse performance indicates significant possibility for collapse increasing.

For instance, only decreasing level of the friction coefficient from current 0.12 (expansion at water base mud) to 0,075 (Brighton film application) leads to the possibility of wall thickness increasing from 0,305" to 0.350" and correspondently to 36% collapse improvement. Application of the best available lubricant (combination of the low friction film and special greases) provides the opportunity increase wall thickness to 0.450" and correspondently to 145% collapse improvement. And finally the application of the best available lubrication (solid film and special grease) and special pipe with high n-value material and heat treatment can increase collapse in more than 3.5 times in comparison with current 6 " X 0.305 " pipe.

The details of this proposal are shown in the presentation.

The co-authors of this proposal (or invention) are Kevin Waddell (idea and preliminary performance evaluation), Jose Menchaca (computer modeling) and Ed Zwald (final pipe wall thickness and collapse performance calculation).

Sincerely,

Mark Shuster, PhD
Senior Technical Advisor
ENVENTURE Global Technology
16200-A Park Row | Houston, TX 77084
phone: 281.492.5039 | cell: 281.615.0770
main: 281.492.5000 | fax: 281.492.5050
mark.shuster@enventureGT.com
www.enventureGT.com

Vikki Meriwether

From: Mark Shuster
Sent: Thursday, August 14, 2003 7:36 AM
To: Vikki Meriwether
Cc: Kevin Waddell; Todd Mattingly; 'todd.mattingly@haynesboone.com'
Subject: RE: Invention addition

Vikki,
Please see an attachment for patent related to collapse performance enhancement proved that pipe material with high n-value significant increases yield (from 50 ksi to more than 100 ksi) and then collapse due work hardening during expansion. For comparison (slide 3) LSX80 yield doesn't change much even after 24% expansion.

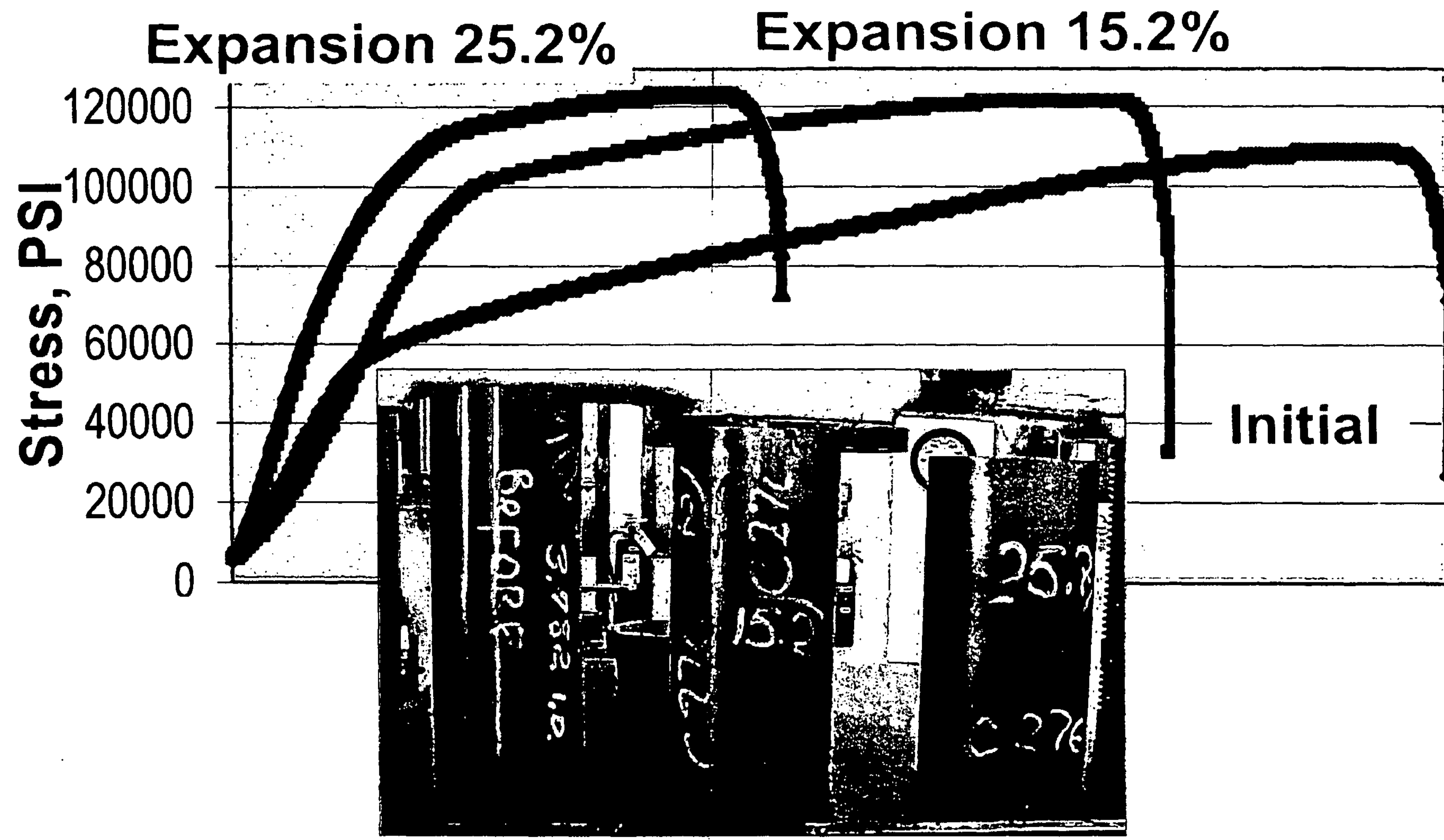
Mark Shuster
phone: 281.492.5039 | cell: 281.615.0770
main: 281.492.5000 | fax: 281.492.5050

-----Original Message-----
From: Vikki Meriwether
Sent: Wednesday, August 13, 2003 4:12 PM
To: Mark Shuster
Cc: Kevin Waddell; Todd Mattingly; 'todd.mattingly@haynesboone.com'
Subject: I forgot to tell you
Importance: High

that the US provisional application we plan to file tomorrow will also contain Invention Disclosures EGT-2003-19 ("Pipe for Expandable Tubular Applications") and EGT-2003-24 (""Decreasing Pipe Collapse Performance," as well as EGT-2003-23. These Invention Disclosures have all been approved for filing and we will name the new application "Expandable Pipe." If you have anything additional for EGT-2003-19 and EGT-2003-24, please give it to me ASAP. Thanks, Vikki

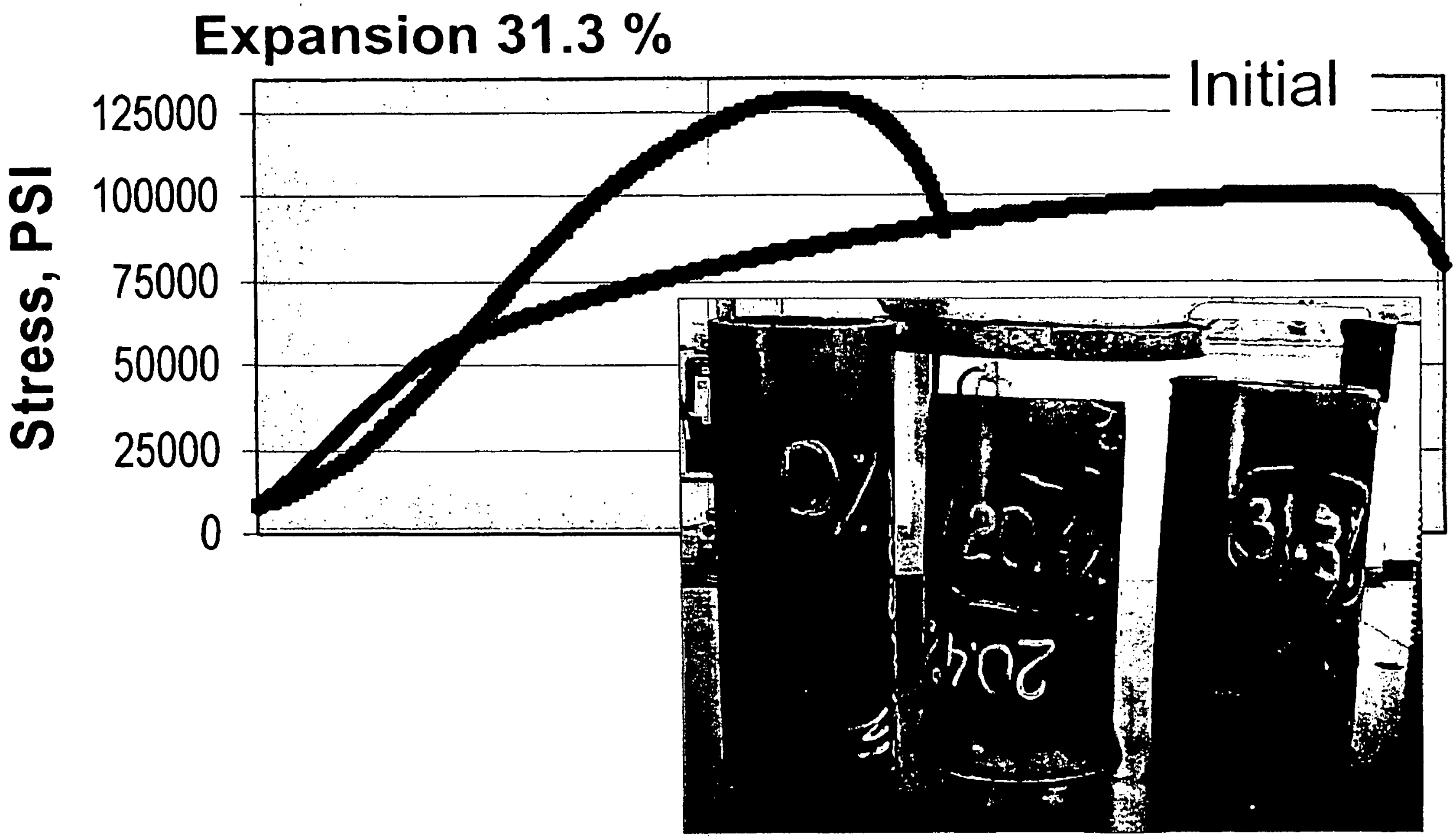
Vikki M. Meriwether
Senior Legal Assistant
ENVENTURE Global Technology
16200-A Park Row / Houston, TX 77084
direct: 281-492-5089
main: 281-492-5000 / fax: 281-492-5826
vikki.meriwether@enventureGT.com
www.enventureGT.com

Engineering Stress vs. Strain Curve
Inconel C 276 material

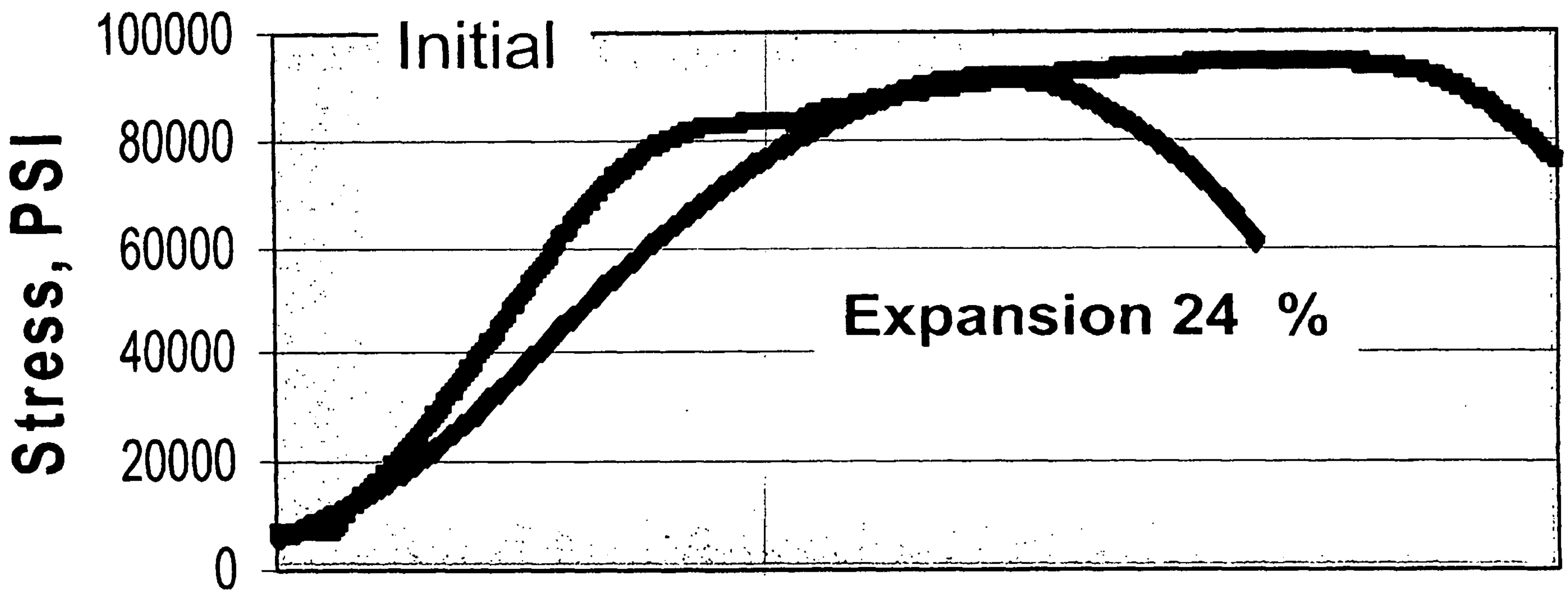


Engineering Stress vs. Strain Curve

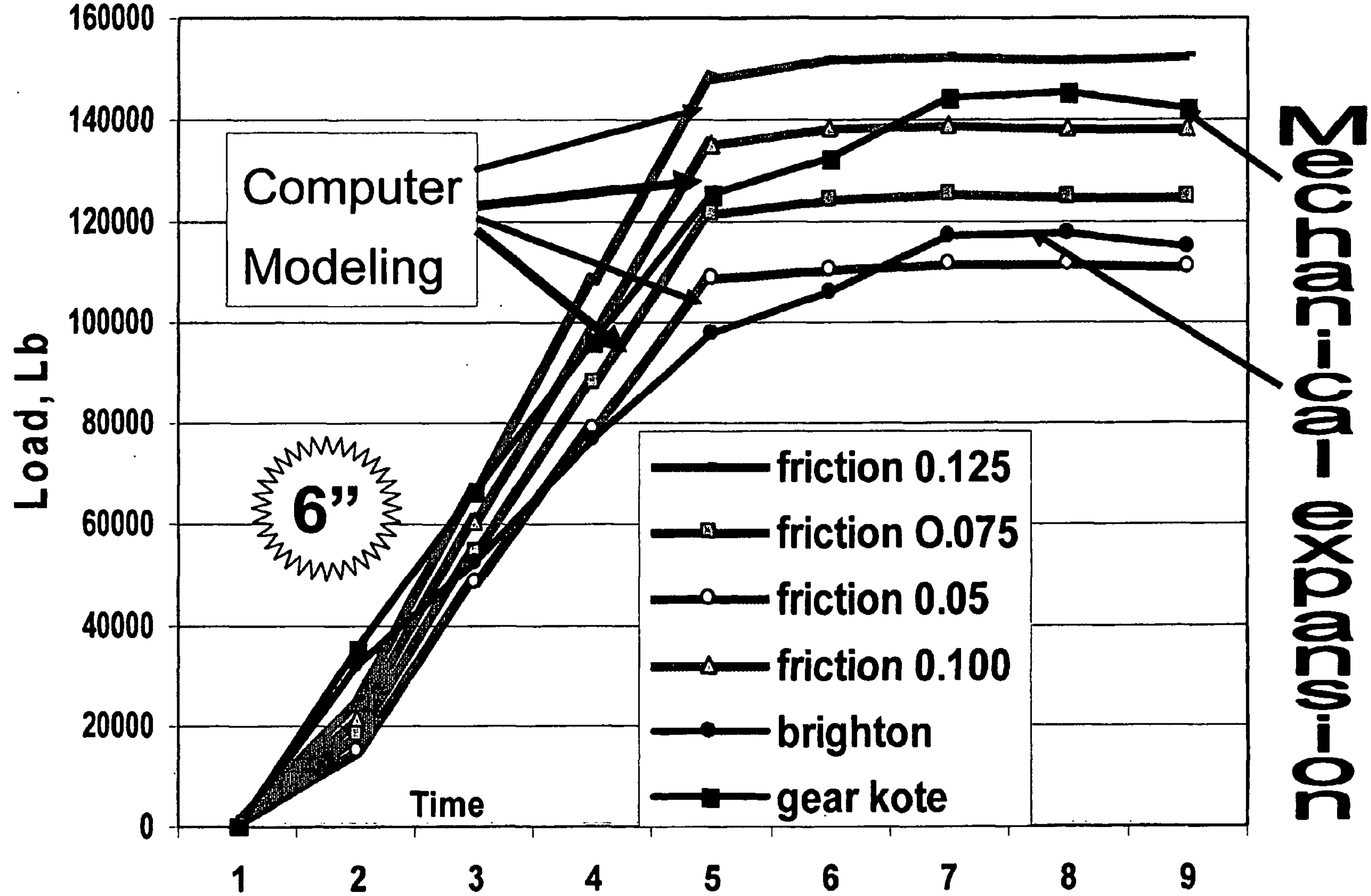
Incoloy 825 material



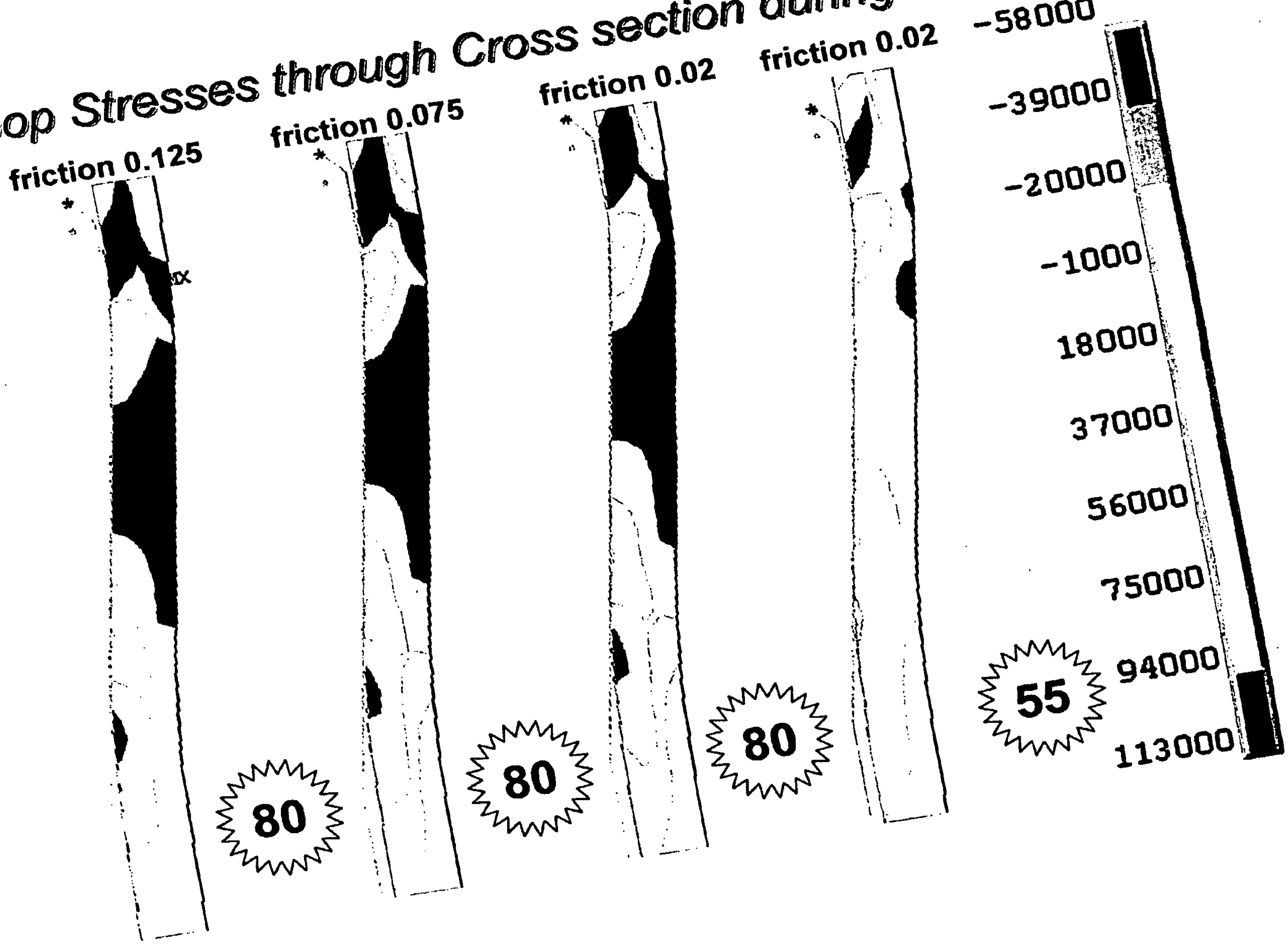
Engineering Stress vs. Strain Curve
LSX80 pipe material



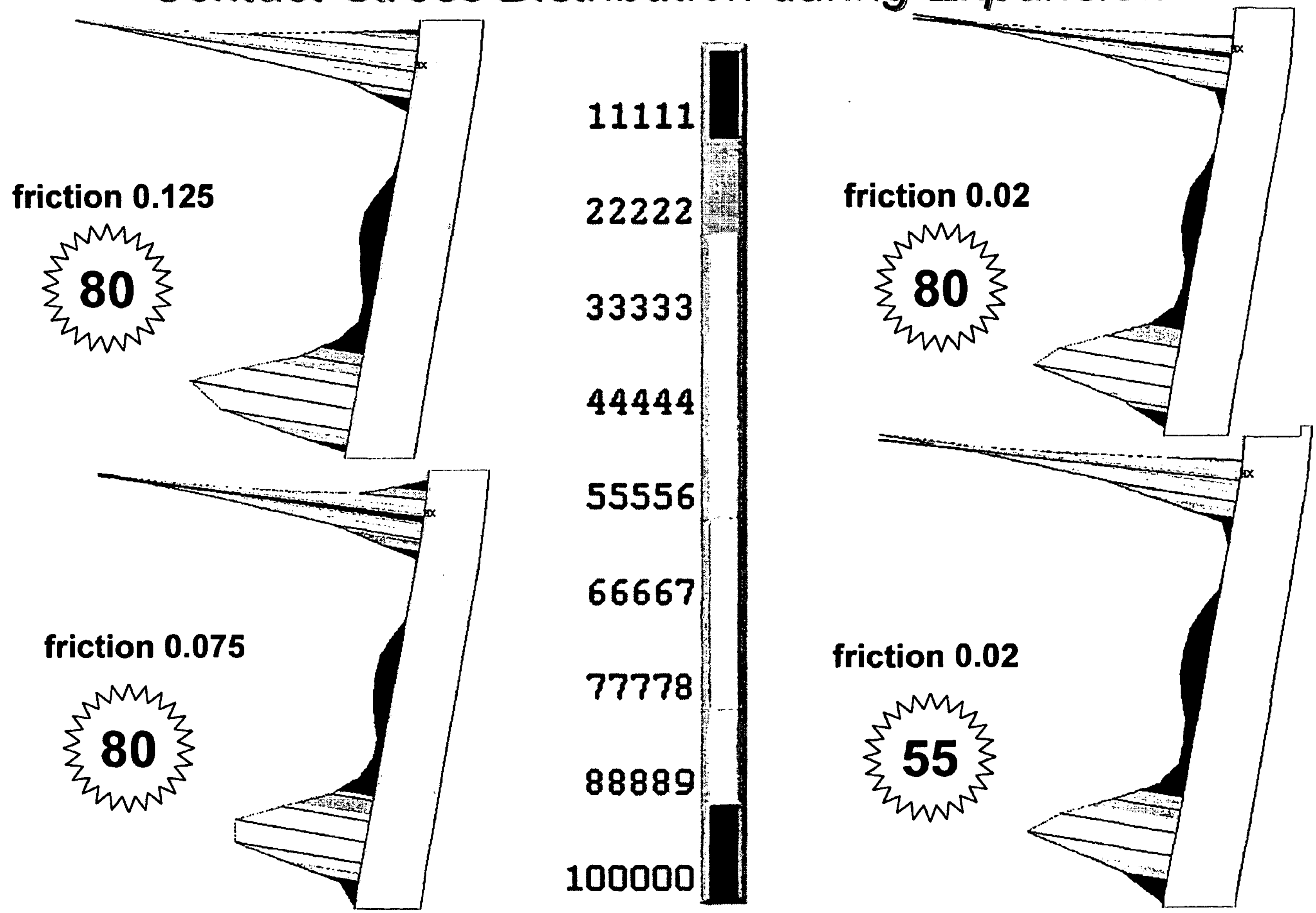
Expansion Load
Computer Modeling vs . Mechanical Expansion



Hoop Stresses through Cross section during Expansion

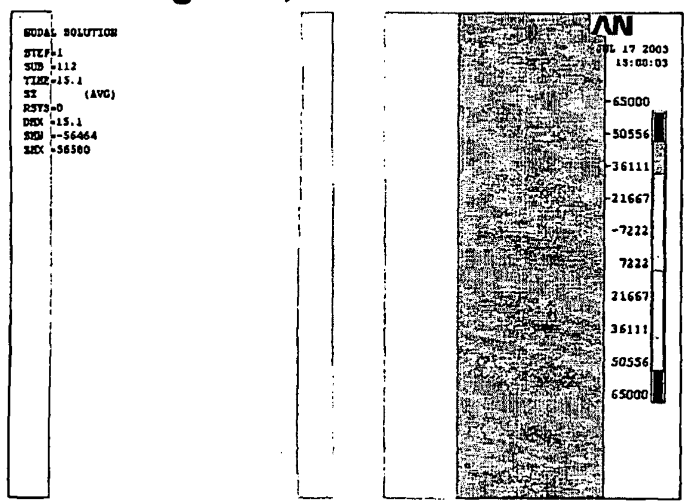


Contact Stress Distribution during Expansion

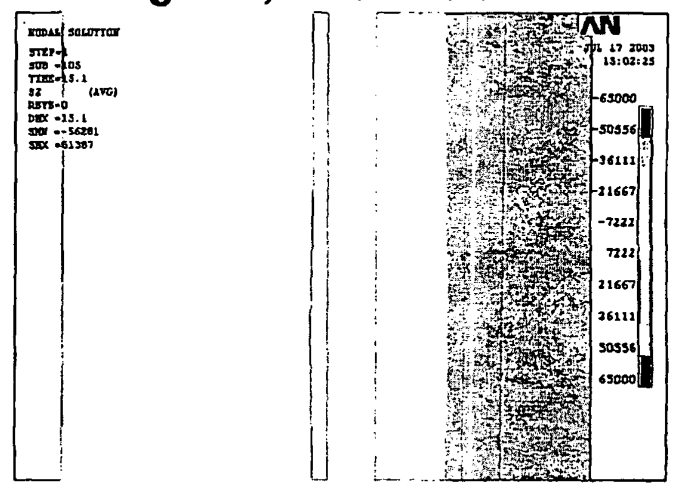


Residual Hoop Stresses through Pipe Cross section

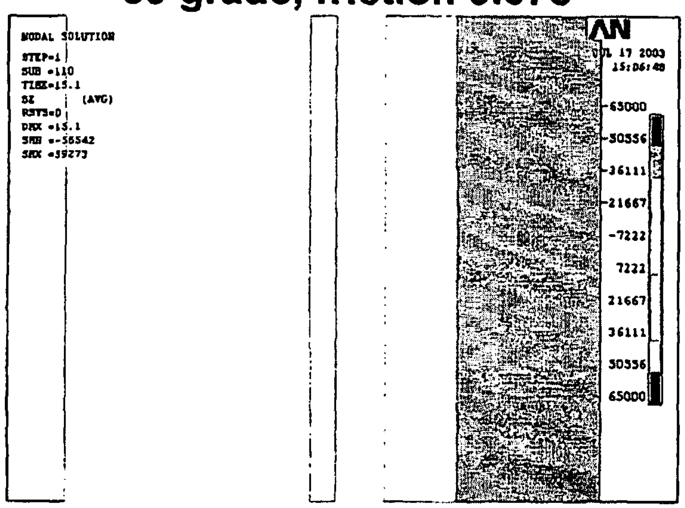
80 grade, friction 0.125



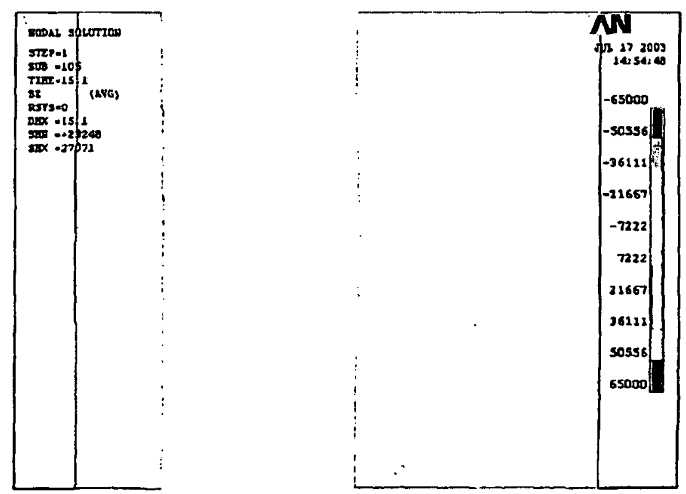
80 grade, friction 0.02



80 grade, friction 0.075

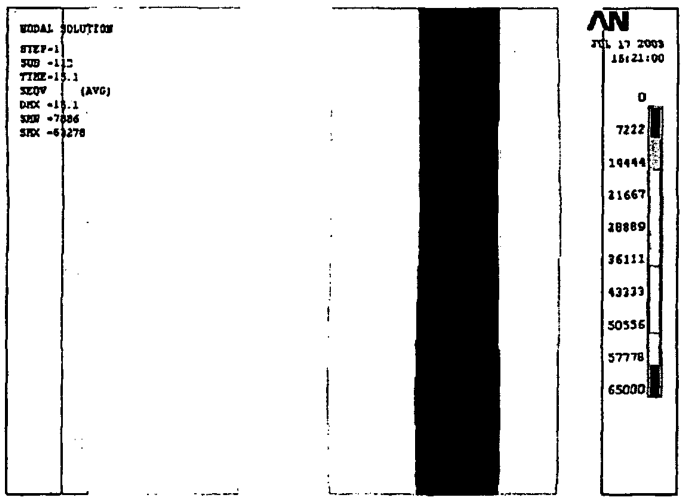


55 K steel, friction 0.02

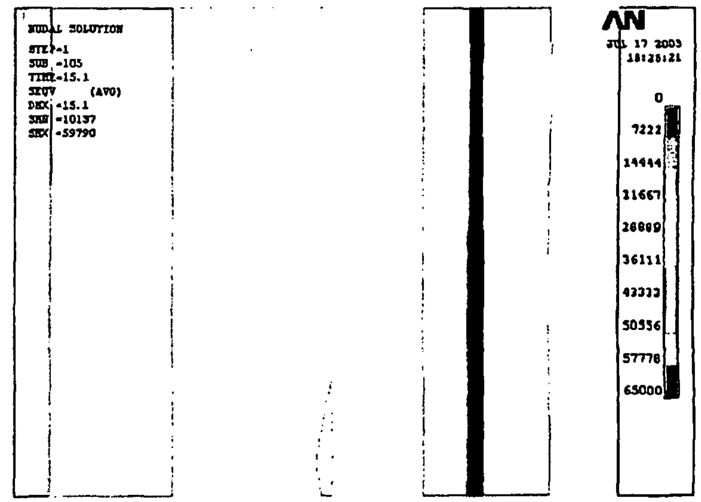


Equivalent Residual Stresses through Pipe Cross section

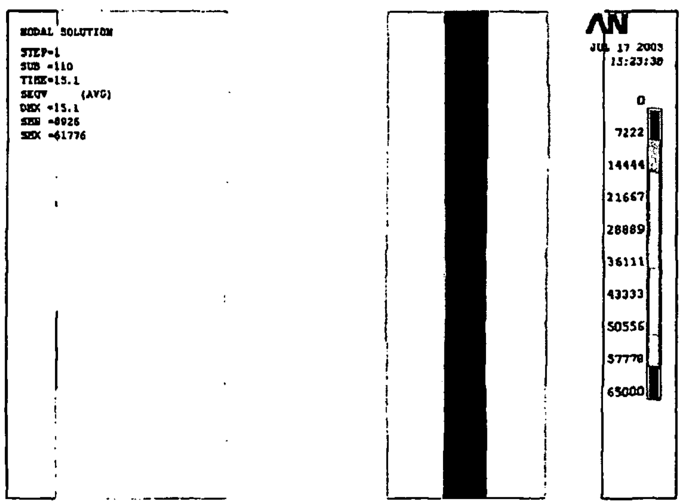
80 grade, friction 0.125



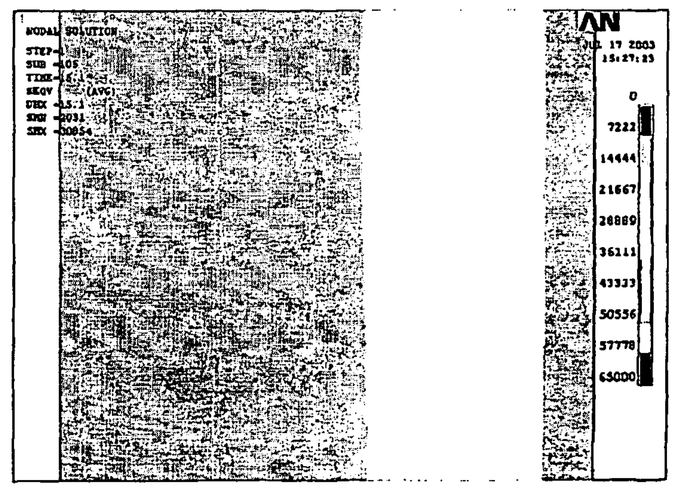
80 grade, friction 0.02



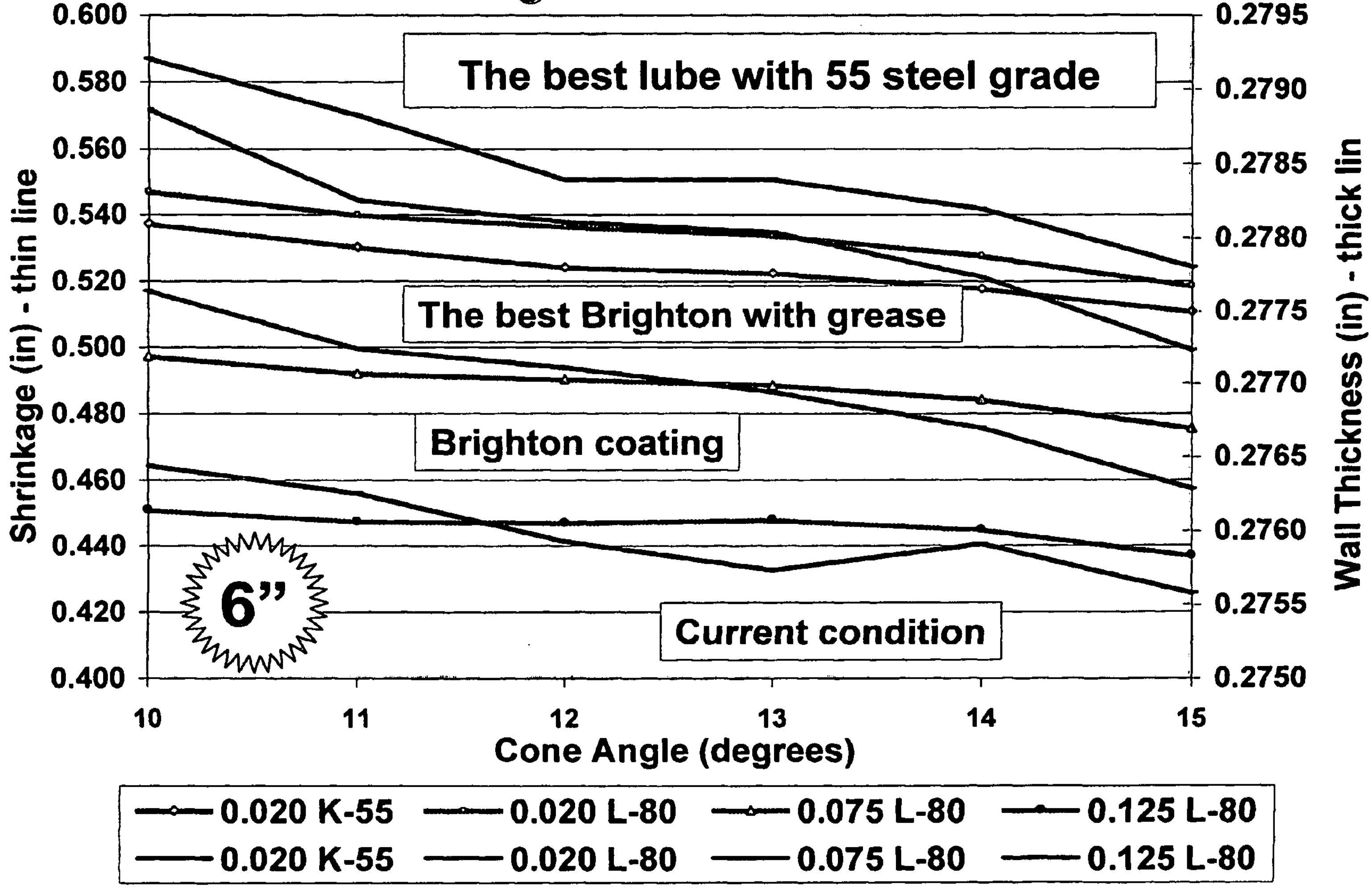
80 grade, friction 0.075



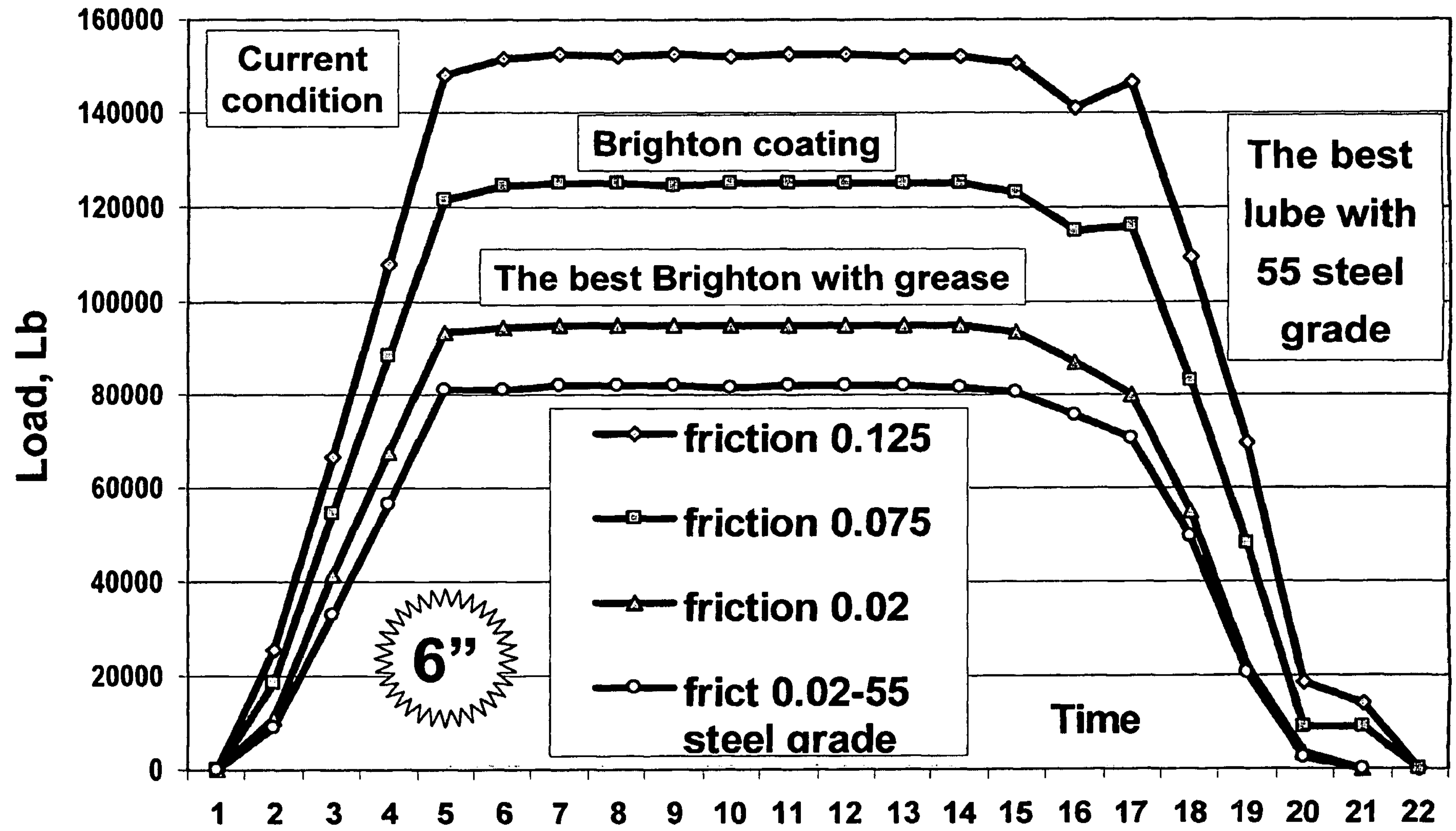
55 grade, friction 0.02



Shrinkage and Wall Thickness as Functions of Cone angle and Friction Coefficient



Load Distribution during Expansion



Collapse Improvement Estimation

6”

	Friction	Expansion force	Wall thickness	D/t after	Collapse Ksi
Current 6” x .305 BSFL lube	**0.125**	**145,900**	**0.305**	**24.8**	**2,379**
Brighton lube Application	**0.075**	**143,000**	**0.350**	**21.6**	**3,243**
Best Brighton With grease	**0.02**	**149,900**	**0.450**	**16.8**	**5,837**
Best lube with 55 ksi steel	**0.02**	**125,800**	**0.500**	**15.1**	**5,359**
Best lube and steel with 55 Ksi yield before and 100 Ksi after pipe expansion	**0.02**	**126,800**	**0.500**	**15.1**	**8,443**

6" Expanded Pipe 80 Ksi	Friction	Exp Force	Pre Wall t	Est Post t	Est Post ID	Post D/t	Collapse
Current 6" x 0.305" Wall	0.125	145.9 Ksi	0.305	0.275	6.269	24.796	2,379
Brighton	0.075	143 Ksi	0.350	0.316	6.188	21.579	3,243
Best Lube	0.02	149.9 Ksi	0.450	0.406	6.008	16.796	5,837
Best Lube w/ 55 Ksi material	0.02	126.8 Ksi	0.500	0.451	5.917	15.120	5,359
Best Lube w/ 55 Ksi material with 100 Ksi Post Exp Yield	0.02	126.8	0.5	0.451	5.917	15.12	8,443
OD for All Cases =	6.819						

ENVENTURE
SET. The Standard.

SET Design Sheet

Rev 1.2B 10/1/02 KKW

Base Casing OD	7.625
Base Casing weight	26.400

Project: 6" 15 % Expansion   Sales Rep.: Mark Schuster

Date: 17/Jul/03   Engineer: Ed Zwald

Pre-Expansion Dimensions

Drift ID for Base Casing	Nom. ID	Clearance	E t	wall t	Tube OD	Tube ID	Launcher OD	Launcher Wall t	AH/HJ OD	D/t
6.844	6.969	0.000	0.140	0.305	6.000	5.390	6.844	0.319	6.280	19.67

Pre-Expansion Pressure Ratings

					Machined			Pressed		
Tube Burst	Tube IY	Tube collapse***	Launcher Burst	Launcher IY	Launcher collapse*	Launcher collapse**	Launcher collapse***	Launcher collapse*	Launcher collapse**	Launcher collapse***
9904	7117	5195	9043	6527	9838	9737	8698	7352	6200	2980

Expansion

Cone OD	% Exp.	Yield Body	Yield Launcher	Cone Angle	Friction	Base Pipe F	P	F_{max} thru elastomer	P	LIY/EXP
6.201	15.0%	80000	80000	10.0	0.125	145,895	4831	204,253	6764	35.1%

Post Expansion

TubeOD	Tube ID	ID Drift	wall t	Burst	IY	collapse***	Clad % 1	Clad % 2	By pass AM	By pass AP
6.819	6.269	6.140	0.275	7778	5653	2384	0.368	0.119	1.36	1.62

* - "Roark"Short section supported
** - API Yield strength collapse
*** - API D/t collapse

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ENVENTURE

SET. The Standard.™

SET Design Sheet

Rev 1.2B 10/1/02 KKW

Base Casing OD	7.625
Base Casing weight	26.400

Project: 6" 15 % Exp, f = 0.075 Sales Rep.: Mark Schuster

Date: 17/Jul/03 Engineer: Ed Zwald

Pre-Expansion Dimensions

Drift ID for Base Casing	Nom. ID	Clearance	E t	wall t	Tube OD	Tube ID	Launcher OD	Launcher Wall t	AH/HJ OD	D/t
6.844	6.969	0.000	0.140	0.350	6.000	5.300	6.844	0.357	6.280	17.14

Pre-Expansion Pressure Ratings

					Machined			Pressed		
Tube Burst	Tube IY	Tube collapse***	Launcher Burst	Launcher IY	Launcher collapse*	Launcher collapse**	Launcher collapse***	Launcher collapse*	Launcher collapse**	Launcher collapse***
11459	8167	7037	10163	7293	12979	9737	8698	10207	7062	4095

Expansion

Cone OD	% Exp.	Yield Body	Yield Launcher	Cone Angle	Friction	Base Pipe F	P	F_{max} thru elastomer	P	LIY/EXP
6.126	15.6%	80000	80000	10.0	0.075	143,053	4853	200,274	6795	50.3%

P st Expansion

TubeOD	Tube ID	ID Drift	wall t	Burst	IY	collapse***	Clad % 1	Clad % 2	By pass AM	By pass AP
6.819	6.188	6.065	0.316	8972	6472	3276	0.366	0.118	1.36	1.62

* - "Roark"Short section supported

** - API Yield strength collapse

*** - API D/t collapse

ENVENTURE

SET. The Standard.™

SET Design Sheet

Rev 1.2B 10/1/02 KKW

Base Casing OD	7.625
Base Casing weight	26.400

Project: 6" 15 % Exp, f = 0.02

Sales Rep.: Mark Schuster

Date: 18/Jul/03

Engineer: Ed Zwald

Pr -Expansion Dimensions

Drift ID for Base Casing	Nom. ID	Clearance	E t	wall t	Tube OD	Tube ID	Launcher OD	Launcher Wall t	AH/HJ OD	D/t
6.844	6.969	0.000	0.140	0.450	6.000	5.100	6.844	0.446	6.280	13.33

Pre-Expansion Pressure Ratings

					Machined			Pressed		
Tube Burst	Tube IY	Tube collapse***	Launcher Burst	Launcher IY	Launcher collapse*	Launcher collapse**	Launcher collapse***	Launcher collapse*	Launcher collapse**	Launcher collapse***
15013	10500	11100	12884	9113	22657	9737	8698	18861	8953	7342

Expansion

Cone OD	% Exp.	Yield Body	Yield Launcher	Cone Angle	Friction	Base Pipe F	P	F_{max} thru elastomer	P	LIY/EXP
5.948	16.6%	80000	80000	10.0	0.02	149,872	5394	209,821	7551	69.0%

Post Expansion

TubeOD	Tube ID	ID Drift	wall t	Burst	IY	collapse***	Clad % 1	Clad % 2	By pass AM	By pass AP
6.819	6.008	5.887	0.406	11703	8330	5874	0.368	0.119	1.36	1.62

* - "Roark"Short section supported

** - API Yield strength collapse

*** - API D/t collapse

ENVENTURE

SET. The Standard.™

SET Design Sheet

Rev 1.2B 10/1/02 KKW

Base Casing OD	7.625
Base Casing weight	26.400

Project: 6" 15 % Exp, f=0.02, Y=55l Sales Rep.: Mark Schuster

Date: 17/Jul/03 Engineer: Ed Zwald

Pre-Expansion Dimensions

Drift ID for Base Casing	Nom. ID	Clearance	E t	wall t	Tube OD	Tube ID	Launcher OD	Launcher Wall t	AH/HJ OD	D/t
6.844	6.969	0.000	0.140	0.500	6.000	5.000	6.844	0.491	6.280	12.00

Pre-Expansion Pressure Ratings

					Machined			Pressed		
Tube Burst	Tube IY	Tube collapse***	Launcher Burst	Launcher IY	Launcher collapse*	Launcher collapse**	Launcher collapse***	Launcher collapse*	Launcher collapse**	Launcher collapse***
11579	8021	8403	14292	10034	28819	9737	8698	24435	6792	6701

Expansion

Cone OD	% Exp.	Yield Body	Yield Launcher	Cone Angle	Friction	Base Pipe F	P	F_{max} thru elastomer	P	LIY/EXP
5.858	17.2%	55000	80000	10.0	0.02	126,780	4704	177,493	6586	113.3%

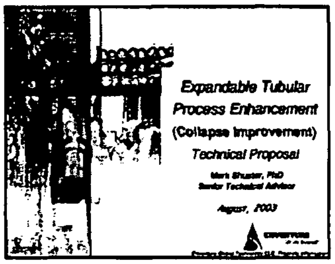
Post Expansion

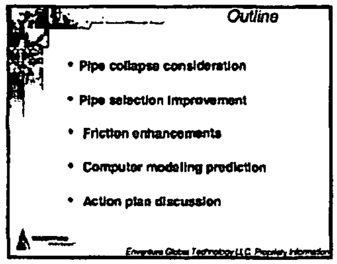
TubeOD	Tube ID	ID Drift	wall t	Burst	IY	collapse***	Clad % 1	Clad % 2	By pass AM	By pass AP
6.819	5.917	5.797	0.451	9007	6364	5361	0.365	0.116	1.36	1.63

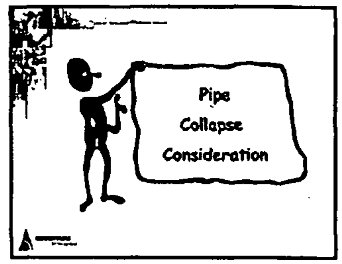
* - "Roark"Short section supported

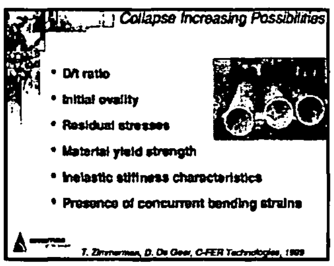
** - API Yield strength collapse

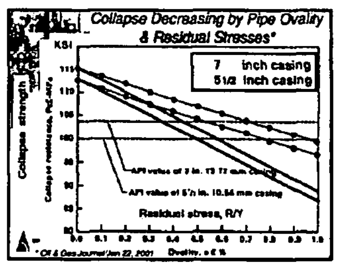
*** - API D/t collapse

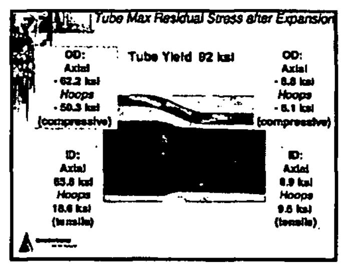

Expandable Tubular
Process Enhancement
(Collapse Improvement)
Technical Proposal
Mark Shuster, PhD
Senior Technical Advisor
August, 2003

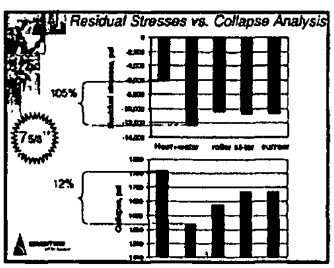

Outline
• Pipe collapse consideration
• Pipe selection improvement
• Friction enhancements
• Computer modeling prediction
• Action plan discussion
Enventure Global Technology LLC Proprietary Information

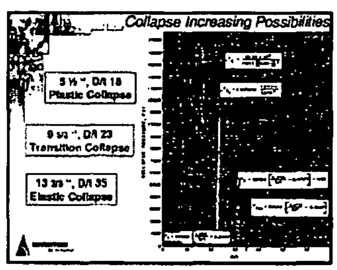

Pipe
Collapse
Consideration

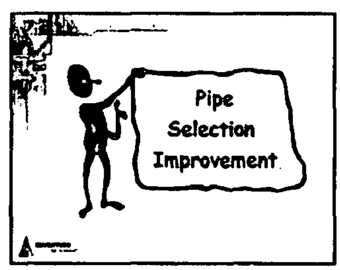

Collapse Increasing Possibilities
• D/t ratio
• Initial ovality
• Residual stresses
• Material yield strength
• Inelastic stiffness characteristics
• Presence of concurrent bending strains
T. Zimmerman, D. De Geer, C-FER Technologies, 1999

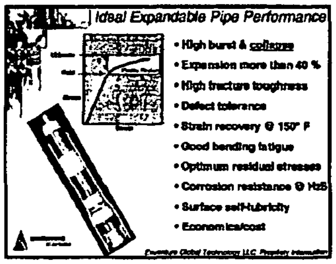

Collapse Decreasing by Pipe Ovality & Residual Stresses*
KSI
7 inch casing
5 1/2 inch casing
Collapse strength
Residual stress, R/Y
* Oil & Gas Journal/Jan 22, 2001

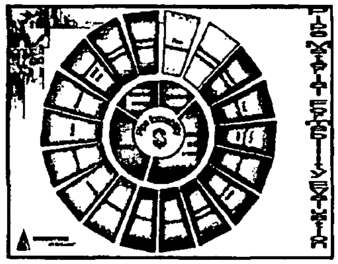

Tube Max Residual Stress after Expansion
Tube Yield 92 ksi
OD:
Axial
Hoops
(compressive)
ID:
Axial
Hoops
(tensile)

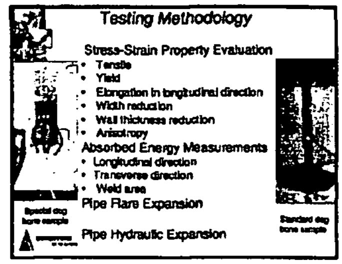

Residual Stresses vs. Collapse Analysis
105%
7 5/8"
12%

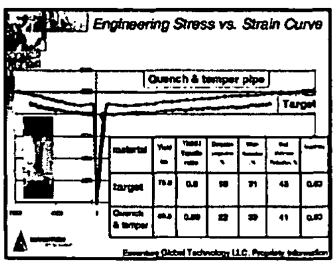

Collapse Increasing Possibilities
5 ½", D/t 18
Plastic Collapse
9 5/8", D/t 23
Transition Collapse
13 3/8", D/t 35
Elastic Collapse

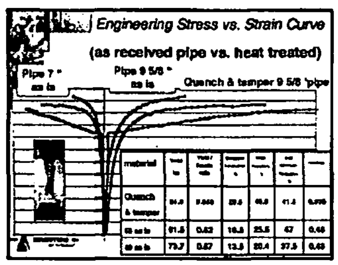

Pipe
Selection
Improvement

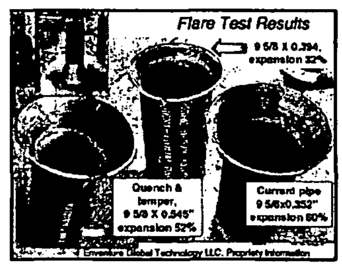

Ideal Expandable Pipe Performance
• High burst & collapse
• Expansion more than 40 %
• High fracture toughness
• Defect tolerance
• Strain recovery @ 150° F
• Good bending fatigue
• Optimum residual stresses
• Corrosion resistance @ H2S
• Surface self-lubricity
• Economics/cost
Enventure Global Technology LLC Proprietary Information

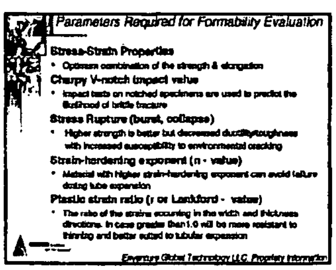


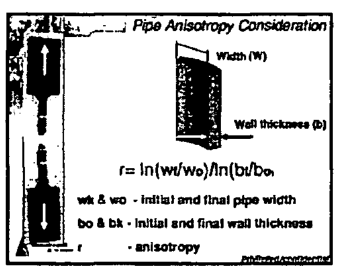

Testing Methodology
Stress-Strain Property Evaluation
• Tensile
• Yield
• Elongation in longitudinal direction
• Width reduction
• Wall thickness reduction
• Anisotropy
Absorbed Energy Measurements
• Longitudinal direction
• Transverse direction
• Weld area
Pipe Flare Expansion
Pipe Hydraulic Expansion
Special dog bone sample
Standard dog bone sample

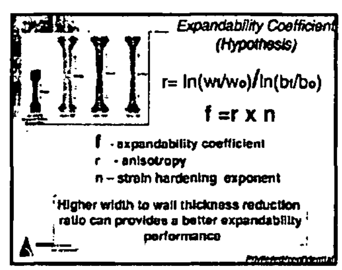

Engineering Stress vs. Strain Curve
Quench & temper pipe
Target
material
target
Quench & temper
Enventure Global Technology LLC. Proprietary Information

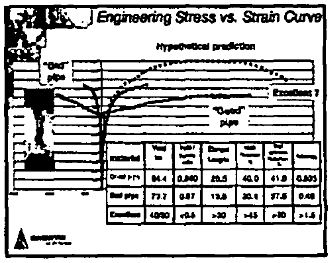

Engineering Stress vs. Strain Curve
(as received pipe vs. heat treated)
Pipe 7 " as is
Pipe 9 5/8 " as is
Quench & temper 9 5/8 'pipe
material
Quench & temper

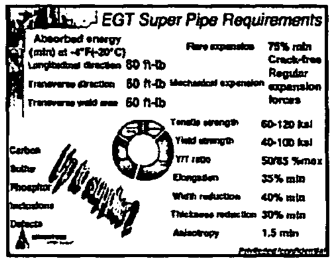

Flare Test Results
9 5/8 X 0.394, expansion 32%
Quench & temper, 9 5/8 X 0.545" expansion 52%
Current pipe 9 5/8x0.352" expansion 60%
Enventure Global Technology LLC. Proprietary Information

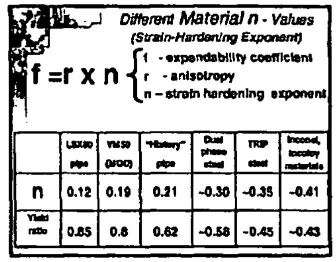

Parameters Required for Formability Evaluation
Stress-Strain Properties
• Optimum combination of the strength & elongation
Charpy V-notch impact value
• Impact tests on notched specimens are used to predict the likelihood of brittle fracture
Stress Rupture (burst, collapse)
• Higher strength is better but decreased ductility/toughness with increased susceptibility to environmental cracking
Strain-hardening exponent (n - value)
• Material with higher strain-hardening exponent can avoid failure during tube expansion
Plastic strain ratio (r or Lankford - value)
• The ratio of the strains occurring in the width and thickness directions. In case greater than 1.0 will be more resistant to thinning and better suited to tubular expansion
Enventure Global Technology LLC. Proprietary Information

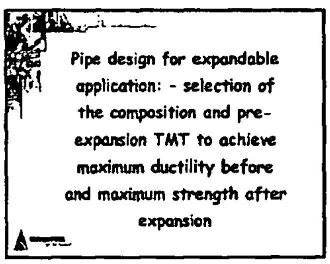

Pipe Anisotropy Consideration
Width (W)
Wall thickness (b)
r= ln(wf/wo)/ln(bf/bo)
wk & wo - initial and final pipe width
bo & bk - initial and final wall thickness
r - anisotropy

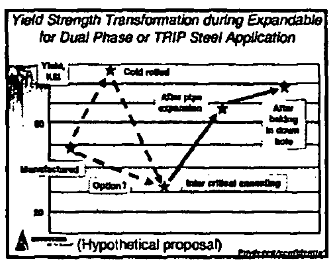

Expandability Coefficient
(Hypothesis)
r= ln(wf/wo)/ln(bf/bo)
f =r x n
f - expandability coefficient
r - anisotropy
n – strain hardening exponent
Higher width to wall thickness reduction ratio can provides a better expandability performance

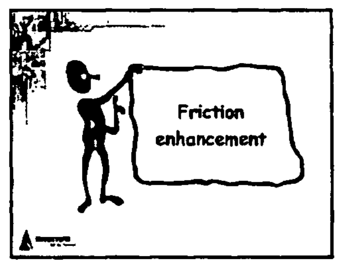

Engineering Stress vs. Strain Curve
Hypothetical prediction
"Bad" pipe
Excellent ?
"Good" pipe

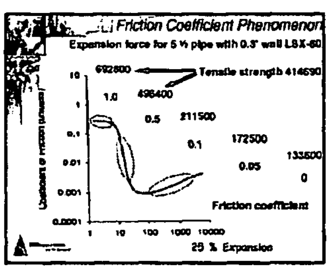

EGT Super Pipe Requirements
Absorbed energy (min) at -4°F(-20°C)
Longitudinal direction 80 ft-lb
Transverse direction 60 ft-lb
Transverse weld area 60 ft-lb
Flare expansion 75% min
Crack-free
Mechanical expansion Regular expansion forces
Tensile strength 60-120 ksi
Yield strength 40-100 ksi
Y/T ratio 50/85 %max
Elongation 35% min
Width reduction 40% min
Thickness reduction 30% min
Anisotropy 1.5 min
Carbon
Sulfur
Phosphor
Inclusions
Defects

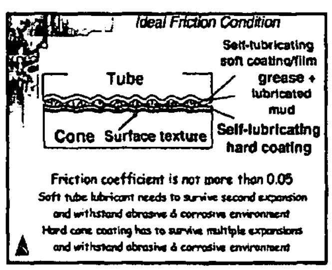

Different Material n - Values
(Strain-Hardening Exponent)
f = r x n
f - expandability coefficient
r - anisotropy
n – strain hardening exponent
LSX80 pipe
YM50 (ASOO)
"History" pipe
Dual phase steel
TRIP steel
Inconel, Incoloy materials
n 0.12 0.19 0.21 ~0.30 ~0.35 ~0.41
Yield ratio 0.85 0.8 0.62 ~0.58 ~0.45 ~0.43

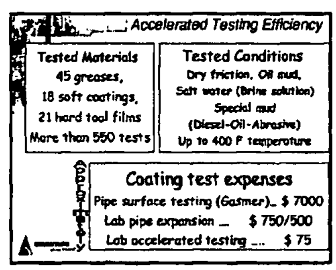

Pipe design for expandable application: - selection of the composition and pre-expansion TMT to achieve maximum ductility before and maximum strength after expansion

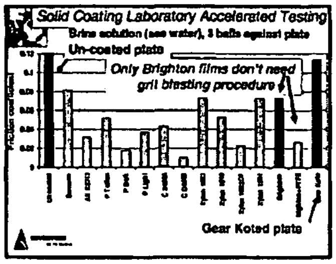

Yield Strength Transformation during Expandable for Dual Phase or TRIP Steel Application
Yield, ksi
Cold rolled
After pipe expansion
After baking in down hole
Manufactured
Option ?
Inter critical annealing
(Hypothetical proposal)

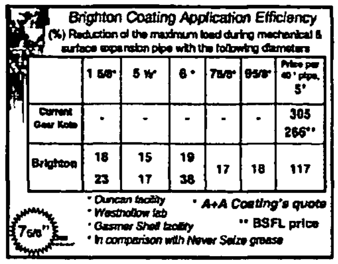

Friction enhancement

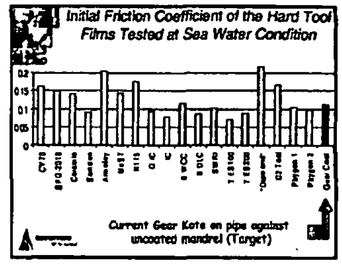

Friction Coefficient Phenomenon
Expansion force for 5 ½ pipe with 0.5" wall LSX-80
692800
Tensile strength 414690
1.0
496400
0.5
311500
0.1
172500
0.05
133600
0
Friction coefficient
25 % Expansion

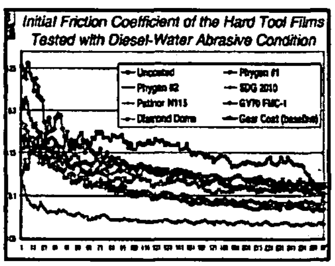

Ideal Friction Condition
Tube
Cone
Surface texture
Self-lubricating soft coating/film
grease + lubricated mud
Self-lubricating hard coating
Friction coefficient is not more than 0.05
Soft tube lubricant needs to survive second expansion and withstand abrasive & corrosive environment
Hard cone coating has to survive multiple expansions and withstand abrasive & corrosive environment

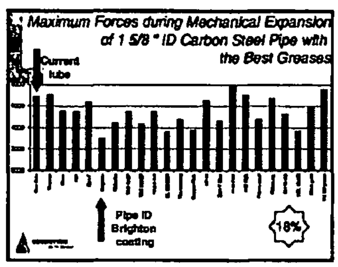

Accelerated Testing Efficiency
Tested Materials
45 greases,
18 soft coatings,
21 hard tool films
More than 550 tests
Tested Conditions
Dry friction, Oil mud,
Salt water (Brine solution)
Special mud
(Diesel-Oil-Abrasive)
Up to 400 F temperature
Coating test expenses
Pipe surface testing (Gasmer)_ $ 7000
Lab pipe expansion _ $ 750/500
Lab accelerated testing ... $ 75

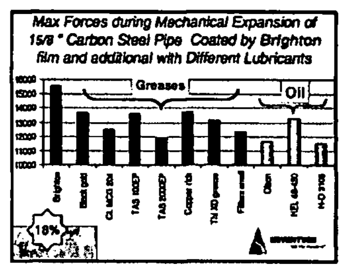

Solid Coating Laboratory Accelerated Testing
Brine solution (sea water), 3 balls against plate
Un-coated plate
Only Brighton films don't need grit blasting procedure
Gear Koted plate

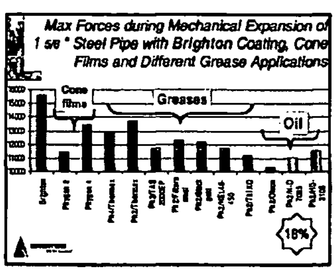

Brighton Coating Application Efficiency
(%) Reduction of the maximum load during mechanical & surface expansion pipe with the following diameters
1 5/8"
5 ½"
6"
7 5/8"
9 5/8"
Price per 40' pipe, 5"
Current Gear Kote
305
266**
Brighton
18
23
15
17
19
38
17
18
117
* Duncan facility
* Westhollow lab
* Gasmer Shell facility
* In comparison with Never Seize grease
* A+A Coating's quote
** BSFL price
7 5/8"

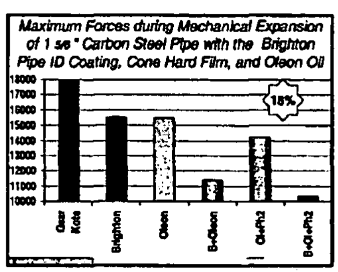

Initial Friction Coefficient of the Hard Tool Films Tested at Sea Water Condition
Current Gear Kote on pipe against uncoated mandrel (Target)

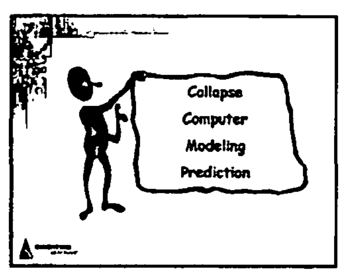

Initial Friction Coefficient of the Hard Tool Films Tested with Diesel-Water Abrasive Condition
Uncoated
Phygen #1
Phygen #2
SDG 2010
Pattnor N115
GY70 FMC-1
Diamond Dome
Gear Coat (baseline)

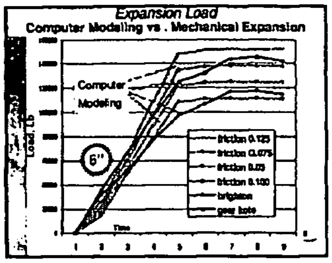

Maximum Forces during Mechanical Expansion of 1 5/8 " ID Carbon Steel Pipe with the Best Greases
Current tube
Pipe ID Brighton coating
18%

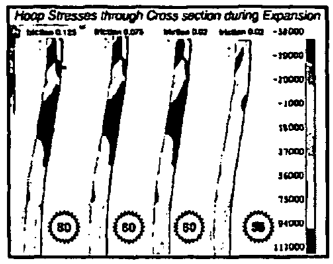

Max Forces during Mechanical Expansion of 15/8 " Carbon Steel Pipe Coated by Brighton film and additional with Different Lubricants
Greases
Oil
18%

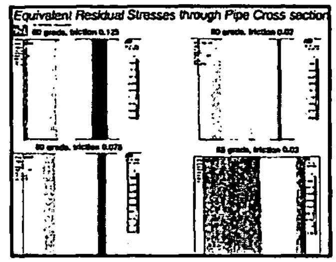

Max Forces during Mechanical Expansion of 1 5/8 " Steel Pipe with Brighton Coating, Cone Films and Different Grease Applications
Cone films
Greases
Oil
18%

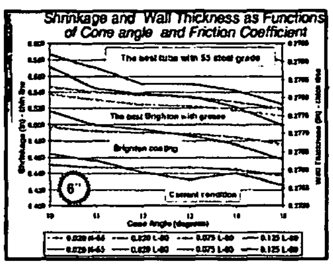

Maximum Forces during Mechanical Expansion of 1 5/8 " Carbon Steel Pipe with the Brighton Pipe ID Coating, Cone Hard Film, and Oleon Oil
18%
Gear Kote
Brighton
Oleon
B+Oleon
Ol+Ph2
B+Ol+Ph2

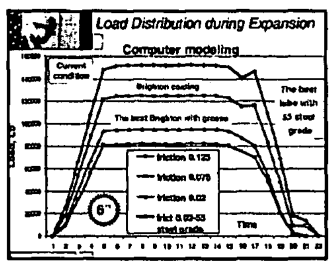

Collapse
Computer
Modeling
Prediction

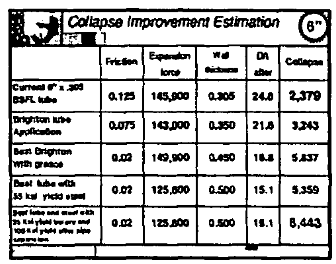












	Friction	Expansion force	Wall thickness	D/t after	Collapse
Current 6" x .305 BSFL tube	0.125	145,900	0.305	24.8	2,379
Brighton tube Application	0.075	143,000	0.350	21.6	3,243
Best Brighton With grease	0.02	149,900	0.450	16.8	5,837
Best tube with 55 ksi yield steel	0.02	125,600	0.500	15.1	5,359
[illegible]	0.02	125,600	0.500	15.1	6,443

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